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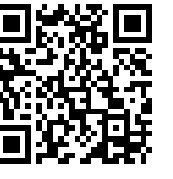

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When Edward I. conducted the war in Wales in 1287, there were 2,000 wood-cutters and sappers employed with the army, and these men were of great service in making roads, cutting paths through the forests, and assisting in the sieges of the Welsh strongholds.

At the siege of Calais by Edward III. in 1347, the Chief Engineer had under him a body of 314 men composed of masons, carpenters, smiths, engineers, tentmakers, miners, armourers, gunners and artillerymen. The last two had become necessary owing to the invention of gunpowder, and the Siege of Calais furnishes the first recorded instance of the use of artillery.

When Henry V. invaded France in 1415, his Chief Engineer, Nicholas Maybury (or Merbury), was styled "Master of the King's Works, Guns and Ordnance." He was the first Master of the Ordnance, and as such he heads the list of past M.G.O.s in the War Office. Maybury received honourable mention for his conduct at Agincourt, but the war was to a great extent a campaign of sieges, and the engineers bore the brunt of them. In the 1417 campaign, no fewer than 1,000 masons, carpenters and other labourers were employed.

Gradually, an Office of Ordnance was formed, to take charge, on behalf of the King, of all matters concerning fortifications, sieges, artillery, and stores. This office developed into the Board of Ordnance, which was established in the Tower of London about 1455, and which existed for exactly 400 years, until it was abolished after the Crimea. Its principal officer became the Master General of the Ordnance, and the Chief Engineer was from early times one of the important officers of the Board. At out-stations, under the orders of the Board, were the following officials :—

Engineers, master gunners, firemasters, proofmasters, fireworkers, storekeepers, wagonmasters, tradesmen and artificers.

Sir Richard Lee, a distinguished Chief Engineer in the reigns of Henry VIII., Mary and Elizabeth, was employed as Head of the Boundary Commission for the delimitation of the Franco-English boundary in France in 1545 ; in the construction of the Castle at Upnor in 1560 ; and was mentioned in dispatches by the Duke of Norfolk in the Expedition to Scotland of the same year for his excellent reconnaissances of Scottish positions. How constant have been the duties of the Royal Engineers. It reads like a page of some R.E. officers' services in the *Army List*. Sir R. Lee had a good-looking wife, who was a friend of Henry VIII., which may have helped her husband. His looting propensities were, I hope, not so characteristic. He looted the Royal baptismal font and a brass eagle lectern from Holyrood Chapel, which he brought back to St. Albans. The font was given to the Abbey and destroyed in the Cromwellian period. The eagle lectern he gave to St. Stephen's Parish Church. It was buried, and dug up in 1750, and is now used.

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It must not be forgotten that when the Board was established in the 15th century, it was the only permanent military office. Commanders, cavalry and infantry, were appointed and raised as required at the beginning of a war, and disbanded at its conclusion. The Board, therefore, as was natural, acquired a very strong position, and when a standing army, comprising infantry and cavalry, was kept up after the Restoration in 1660, and placed directly under the King, or a general deputed by him to command the Forces, there was jealousy between those branches of the army and the officers of the Engineers and Artillery who owed allegiance to the Master General of the Ordnance and his Board, and were independent of the Commander-in-Chief. Is some faint echo of a note of challenge to be detected in the title assigned to me for my lecture this evening? What hast thou to do with us?

Up to the beginning of the 18th century, the Engineer and Artillery Services formed one Corps, detachments from which were placed at the disposal of the Commander-in-Chief in the field at the beginning of each campaign by the Master General of the Ordnance. After Marlborough's wars, the importance of having a permanent body of gunners instead of raising a train for each campaign led to the formation of two permanent Artillery Companies in 1716; and the Engineer Corps, composed of 1 Chief Engineer and 27 other officers, received a separate constitution. The men were still raised as required for each particular campaign, and it was not until 1772 that a permanent force of non-commissioned officers and men was established for service at Gibraltar, while in 1787 a Corps of six companies was founded, known as Royal Military Artificers, and commanded by officers, styled "Royal Engineers." In 1802, the Chief Engineer became the Inspector-General of Fortifications. The Peninsular War saw the name Artificers changed to Royal Sappers and Miners—a title still in use in India; but it was not until the end of the Crimea, in 1856, that the two Corps, Royal Engineers Officers and Sappers and Miners, finally became the Corps of Royal Engineers.

In Russell's letters from the Crimea he remarks on the excellence of the clothing and equipment of the Engineers and Artillery, who were under the Board of Ordnance, as compared with the other fighting arms who were equipped by the Horse Guards under the Commander-in-Chief.

The formation of the Corps of Royal Engineers synchronized with the disappearance of the Board of Ordnance, and the chief officer of the Corps, the Inspector-General of Fortifications and Royal Engineers, was placed directly under the Commander-in-Chief, and remained so until 1904. He became responsible for the construction and maintenance of fortifications, barracks, store buildings and the inspection of ordnance factory buildings, for military railways, telegraphs and balloons, the custody of War Department lands and

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unoccupied buildings, the design, inspection and custody and issue of Engineer stores, and—here we get the first connection with the Quartermaster-General—in concert with the Quartermaster-General the preparation of the annual estimates for Engineer services. As Inspector-General of Royal Engineers, he advised as to the general distribution of the Corps, and as to the appointment of officers to, or their removal from, responsible positions in connection with works. He inspected the Corps of Royal Engineers and advised on all questions relating to its technical instruction.

Looking back on the history of the Royal Engineers through the 19th century, certain prominent factors emerge. At the beginning of the century, they were—if we except the officers of the Royal Artillery—the only strictly professional officers of scientific attainments, and they were, as a class, men of higher education than the bulk of the officers of the army. These qualities, and the absence of any sort of peace training for the duties of the Staff, gave to the Royal Engineer officer an outstanding position in war and perhaps especially in India, where the standard of military proficiency among the officers of the Honourable East India Company's Forces was not so high as in the Home army. The Peninsular War provided practical training for Commanders, Regimental Officers and Staff, but the latter was composed almost entirely of men of family, many of them personal friends or family connections of the Commander.

At Sandhurst, after 1812, there was a senior department at which some few officers were trained for the Staff, but their instruction was, for the most part, concentrated on mathematics, astronomy, survey and fortifications; with little bearing on practical war or Staff problems, and sufficient only to give them a smattering of the knowledge already possessed by the Royal Engineer officer. And they were regarded as cranks and were seldom employed on the Staff.

We have only to look at the history of the Crimea, the Mutiny and the Chinese War of 1860, to realize the important place that was occupied by the Royal Engineer in the army. Gordon is only one name. Anyone who knows Delhi and has visited the little concrete blocks which mark the emplacements of the British batteries at the siege in 1857, must have remarked how the descriptive plaques give the name of the Royal Engineer who erected the battery. The batteries were named after him, and no mention is made of the officer or the unit of Artillery holding the emplacement.

The lessons of the Crimea, and the Mutiny, and the military successes of Prussia in the Wars of 1864, 1866 and 1870, led to a realization of the need of a more professional outlook on the part of the officers of the British Army, and of the importance of their professional education. A Staff College was instituted in 1858, promotion by purchase in the cavalry and infantry was abolished in favour of seniority, tempered by selection and by examinations

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for promotion. Gradually, therefore, and greatly owing to the influence of Lord Wolseley and his associates, a higher standard of professional attainments was secured in the officers of the army. During the same period we can observe the growing power of artillery fire, and of the cult of mobility, so that war was losing much of its dependence on the precise science of the construction, the attack and the defence of permanent fortifications. At the same time the increasing technicality of the science of engineering, and the parallel increasing demands of armies in the field on the works services of the Engineers, enhanced the importance of the Royal Engineers in their technical capacity as Works Officers.

It seems to me, then, that by the end of the 19th century, the army relied less on the Royal Engineers for general professional knowledge and more for technical engineering science as regards works. But certain Royal Engineer officers had been attracted to the Staff College and to a career on the Staff and in command, as distinct from purely Royal Engineer duties. Such names as Lord Nicholson, Sir Richard Harrison, Bindon Blood, Lawson and Hunter-Weston will occur to you at once, not to mention Lord Kitchener, Rundle, Chermside, Aylmer and Hart. The welding of the officers of the Board of Ordnance and of those under the Commander-in-Chief into one composite whole had progressed surely since the Crimea; but the army still thought in terms of peace routine rather than of war preparation.

And just as the Crimean War had brought out the disadvantages, delays and administrative chaos resulting from the dual responsibilities of the Commander-in-Chief and the Board of Ordnance, so the South African War emphasized the dangers of the overloading of the Commander-in-Chief, who dealt direct with seven departments in the War Office, with administrative functions in peace; the absence of systematic preparation for war, and of a military body definitely charged with the duty of advising the Government on military policy.

After the South African War, a Royal Commission under Lord Elgin was appointed to investigate the organization and administration of the army during the war, and a special report upon the organization and equipment of the Engineer arm was submitted to it. Maj.-Gen. Sir Elliott Wood, who went out as Chief Engineer, strongly pressed upon the Commission that Engineer officers should be attached to the Divisional Staffs of Generals.

This view was also that of Sir Charles Warren, who said that :—

> "One of the most retrograde steps taken in recent times was to remove the Commanding Royal Engineer of a Division from his position on the Staff of the Divisional General. The result has been chaos in many directions. How is it possible for a general officer to have his arrangements made

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in advance for crossing rivers, telegraph services, engineer services generally, if his Commanding Royal Engineer is cut off from him and reduced to the position of the officer commanding a battalion ? "

As a result of the Elgin Commission report, a Committee, consisting of Lord Esher, Lord Fisher and Lord Sydenham, was appointed to advise on the reconstitution of the War Office and of the system of command and administration of the army. The principal results of this Committee were the abolition of the office of Commander-in-Chief in peace, and the formation of the Army Council, and of the General Staff, with the separation of command from administration.

Among high offices which disappeared was that of the Inspector-General of Fortifications. His duties were to be combined with those of the Armaments Branch under the 4th Military Member of the Army Council, the Master General of the Ordnance. The entire technical work of the Royal Artillery and Royal Engineers was again brought under one head, thus reverting to the conditions of the Board of Ordnance, but without its responsibility for personnel, which had passed to the Adjutant-General, the 2nd Military Member of the Council. For many years the handling of questions of defence had suffered from dual administration, the R.A. and R.E. not always working together over fortifications and armaments. From 1904, therefore, the Master General of the Ordnance had under him a Director of Artillery and a Director of Fortifications and Works, the latter charged with :—

Design and construction of works of defence ; of all store buildings ; of barrack services not exceeding £2,000 in cost ; and of barrack maintenance generally ; and the administration, but NOT the purchase of, W.D. lands.

Barrack buildings exceeding £2,000 were placed under the Under-Secretary of State, a civil and political Member of the Council.

The functions of the four Military Members of the Army Council may be summarized as follows :—

General Staff Branch.—Policy, Operations, Intelligence, War Organization, Training.

A.G. Branch.—Personnel and Discipline and Mobilization.

Q.M.G. Branch.—Movement, Maintenance, Accommodation.

M.G.O. Branch.—Production, Armament, Works.

In war, the M.G.O. was not directly represented in the field, and the Director of Works came under the Q.M.G., where Lord Esher had wished to place him in peace.

An Engineer-in-Chief was to be appointed to G.H.Q. in war, and his duties would consist of advice to the General Staff, or rather, perhaps, it would be better to say arrangements for the General

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Staff, regarding the distribution of engineer units; the allocation of field engineering work; the collection and distribution of engineer intelligence, except that regarding the enemy's engineers, and the preparation of schemes for large scale demolitions. He would arrange through the Q.M.G. Branch for the distribution of the engineer stores produced or held by the Director of Works, and he acted as a buffer between the D.W. and the Staff in balancing demands for stores with the possibilities of supply.

He also acted as Inspector in the Field to ensure that G.H.Q. orders regarding the employment of engineer units were obeyed, and that G.H.Q. schemes for field engineering works were properly executed.

During what we may call the Renaissance period, before and during the Great War the incorporation of officers of the Royal Engineers in the outside activities of the army as Commanders and Staff Officers continued. The names of Generals Kirkpatrick, Gorringe, Fowke, Macdonogh, Ronald Maxwell, Lee, Fraser, Capper, Charles, Swinton, Elles, Twining, Bowman-Manifold, are some of them. The Manchurian War gave warning—for the most part unheeded—of the continued importance of field engineering in modern war.

The Great War has been styled an infantry war, an artillery war, and an engineers' war, and there are good claims to each title, which I need not discuss. Certainly the Royal Engineers can claim that the abolition of their special position under the Board of Ordnance 60 years before had served only to enhance their position in the army, not only in respect of their technical functions as Engineers, but also as Commanders and Staff Officers. They no longer stood detached, but their influence permeated the army.

Consideration of the higher organization of the army during the Great War tended to show that once more the Commander-in-Chief was in danger of being overloaded with detail. As the War progressed, with its extension of technical and scientific functions, too many advisers had crowded G.H.Q., nearly all with the right of access to the C.-in-C. At the same time, the question of the supervision of army ordnance stores, of reserves of ammunition, explosives and other ordnance stores, to be maintained in the theatre of operations, and the requirements of research, design and experiment, in connection with ordnance stores, mechanical transport, engineer and signal equipment, had given rise to a demand for the representation of the M.G.O.'s Branch in the field.

As regards peace distribution of duties at the War Office, there were obvious administrative and economic advantages in concentrating under one head the Q.M.G. services of accommodation and the R.E. works services, which were responsible for the erection and maintenance of that accommodation. The latter, as already mentioned, were under the M.G.O. in peace, and the Q.M.G. in war.

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After discussion which covered some years, effect has been given to these considerations by decisions, of which the following directly affect the Royal Engineers :—

(*i*) The Commander-in-Chief in the Field to be assisted by four Principal Staff Officers :—The C.G.S., Deputy A.G., Deputy Q.M.G., Deputy M.G.O.

(*ii*) The Works Service, under the Director of Fortifications and Works (renamed Director of Works), to be transferred from the M.G.O. to the Q.M.G. in peace—it already was there in war.

(*iii*) The appointment of Engineer-in-Chief (amongst others) to be abolished in war.

In accordance with these decisions, the new *Field Service Regulations, Vol. I*, which will shortly be issued, contains important alterations in the Staff at G.H.Q., which deals with Engineer matters. Below G.H.Q., that is, in armies (when formed), corps and divisions, where the work of the C.E. or C.R.E. is executive as well as advisory, no change is made in the existing organization.

In order to secure the limitation of access to the Commander-in-Chief, advice on technical matters will not be given direct to him unless he definitely so desires, but officers of technical arms will form part of, and be attached to, the appropriate branches of the Staff, so that their advice will be rendered through the four principal Staff officers, according to their various functions.

In the rearrangement of Engineer duties consequent on these considerations, the better co-ordination of Engineer work will be ensured by making one senior Engineer officer, named the Director-General of Engineer Services, working under the Q.M.G., responsible for the technical supervision of all Engineer work, and for the supply of all Engineer stores from base to front. It will be remembered that the responsibility of the Engineer-in-Chief did not extend to the lines of communication, and moreover, that though he advised the General Staff on the rationing of Engineer stores, he had no control over the Director of Works, who was responsible for producing these stores.

Let us consider Engineer duties in war as they appertain to the functions of the four principal Staff officers.

General Staff (*Policy*).

R.E. duties under the General Staff are allotted to a section of the General Staff Branch under the Director of Staff Duties, composed of R.E. Staff officers, headed probably by a Colonel. The section will be charged with the duties of organizing Engineer work in accordance with the general plan of the General Staff, with the forecasting of future needs, with the collection and dissemination of information required by the R.E., and with the training of Royal

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Engineers in the field. Although the technical knowledge of the officers composing the section will obviously be at the disposal of the General Staff, the section will not be responsible for technical advice on Engineer matters. This will be a matter for the Director-General of Engineer Services.

Adjutant-General (*Personnel*).

The requirements of R.E. personnel, as of other arms, will be a responsibility of the Adjutant-General, on whose Staff there will be R.E. Staff officers, corresponding to the A.G.7 Section at the War Office.

Quartermaster-General (*Movement and Maintenance*).

Under the Quartermaster-General, the remaining functions of the Engineer-in-Chief, with additional duties, will be performed by a senior R.E. officer, styled the Director-General of Engineer Services. He will be a Major-General, and will be the senior Royal Engineer officer at G.H.Q. for technical duties.

In the words of the new *Field Service Regulations*, "he will exercise a general supervision of the technical methods to be employed by Engineers in the Field." He will issue instructions on technical R.E. matters for the guidance of Chief Engineers of armies (when formed), of Corps and C.R.E.s of Divisions. He will have the power of inspection, in order to see that his instructions are carried out, and he will be available at G.H.Q. for technical advice. Strictly speaking, he will not intervene in the affairs for which the Engineer Section of the General Staff are responsible, but it is not possible (at any rate for me) to envisage a situation in which professional jealousy could intervene to prevent the advice of the most experienced and senior Engineer at G.H.Q. being sought by the General Staff Section on all major engineering problems.

These may be called the supervisory and advisory duties of the Director-General of Engineer Services, but in addition, he will be the executive Head of two Directorates. Under him will work: firstly, the Director of Works, responsible for the arrangement of all Engineer works required at the base and on the lines of communication. This will include work for the transportation service, if there are no special construction units available in that service. Secondly, the Director of Engineer Stores, responsible for the provision of all Engineer stores, both "bricks and mortar" for the Works Service, and "sand-bags and barbed wire" for Field Engineers. Some of these stores must come from overseas, while others will be produced in the field. The Director of Engineer Stores will hold and distribute those coming from abroad, and will establish factories, sawmills, quarries, etc., for those which can be produced in the theatre of operations. It will be remembered that formerly the store duties were performed by the Works Services,

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who were thus called upon to feed both themselves and Field Engineers. Such an arrangement entailed the disadvantage that when, as must very often happen, the Stores available were not equal to all the demands of R.E. in the theatre, either the Works Services or the Field Engineers had to go short, with a general prevailing doubt on the part of the forward areas as to the spirit of self-sacrifice of the Works Service.

The Director of Engineer Stores will be neutral, and the Director-General of Engineer Services will be in a position to survey the whole area of Engineer activity, so as to instruct the Director of Engineer Stores regarding the allotment of stores on a basis best calculated to forward the plans of the Commander-in-Chief. It is easy to raise difficulties that here he may be in conflict with the Engineer Section of the General Staff, whose duty is the policy as regards engineer work and the distribution of Engineer units. No organization can work on a basis of mutual suspicion and departmental opposition. It is obviously no use the General Staff making plans to push forward a road, and sending road construction companies to work on it, if the Director-General of Engineer Services has allotted all his quarrying and road-making plant for the construction of roads at the base. It is possible to multiply such causes of difficulty. They may arise in any organization, and the personal factor must always be of importance in a large organization of the nature of General Headquarters. The importance of close co-ordination of the work of the General Staff and the Quartermaster-General's Branch in war is a truism. That such close co-ordination must exist between the officers of the Royal Engineers serving in Staff and technical capacities must also be axiomatic. It will be the duty, in case of necessity, of the C.G.S. and the Deputy Quartermaster-General to see that the experience of the Director-General in all technical engineering questions is not ignored by the Head of the General Staff R.E. Section, and that the Director-General is doing everything possible to further the plans of the General Staff by ensuring that the most suitable Engineer stores and plant are available when and where required, and that the best and quickest methods are employed by the R.E. in the execution of their work.

All this may appear self-evident. I mention it only because it is on these lines that objections have been raised to the new organization.

The new *Field Service Regulations* has, of intent, refrained from a very exact definition of the respective spheres allotted to the Director-General of Engineer Services and the Engineer Section of the General Staff. It will be necessary, by means of Staff Exercises and Training in peace, to define these more clearly. What stands out is, that the new Director-General of Engineer Services will, in effect, be a Consulting Engineer to G.H.Q. and Inspector of Engineers in the field,

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Executive Engineer for all works up to railhead, and to some extent beyond, and purveyor of Engineer Stores. A position of great importance has thus been created, and on a firmer basis than that of the former Engineer-in-Chief.

The Fourth Principal Staff Officer (M.G.O.), Research, Experiment and Design.

The requirements of research, experiment and design of Engineer Stores and of mechanical vehicles, will call for the employment of R.E. officers under the Deputy Master-General of the Ordnance.

Let me now take an imaginary situation to illustrate the relationship between the Director-General of Engineer Services, the R.E. Section of the General Staff and Chief Engineers of formations.

The Commander-in-Chief intends to move I and II Corps forward across a wide river, and over 60 miles of roadless, waterless country, leaving III Corps to guard his right flank and L. of C. by establishing a chain of posts.

The General Staff prepare the operation plan for the advance. The R.E. Section of the General Staff appreciate that the Engineer plan will have to include a M.T. road over 10 miles of loose sand, also water development at certain points on the road, one heavy and one medium bridge on each corps front, and a system of defences including extensive obstacles in the III Corps area.

Before making the Engineer plan, the R.E. section of the General Staff would consult the D.G.E.S. on such points as best type of road, having regard to stores, labour, transport, and time available. Whether existing water sources can be exploited, or whether water should be piped from existing sources; whether tube wells could be sunk; how the available pontoon equipment should be allotted between I and II Corps. The D.G.E.S. would also be asked to produce estimates of time, Engineer units, stores, and labour required for the road, with semi-permanent bridging, water development, and defences and communications of the III Corps. R.E.(G.) will then formulate their plan, allotting R.E. units to corps. The plan would include the allotment of store tonnage on the basis of estimates obtained by D.G.E.S. from Chief Engineers, and the arrangements, in conjunction with the Quartermaster-General's Branch, for extra labour and transport required. The dividing line between Director of Works and Chief Engineer, III Corps, will be laid down as regards R.E. work in L. of C. defences.

As a result of above, Engineer instructions, drafted by the R.E. Section of the General Staff, will be issued with operation orders. It will be necessary for D.G.E.S. to issue supplementary instructions to Chief Engineers on technical points of design and construction, dealing with specific types of work.

Once the above is issued, it is for the D.G.E.S. to see that the

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methods on which his advice and estimates were based are followed by C.E.s. For instance, that the C.E., I Corps, constructs a plank road, and does not use wire mesh or stone, and that the plans and specifications laid down in his technical instructions are followed. The position of the D.G.E.S. towards Chief Engineers will, therefore, approximate to that which exists in peace between the Director of Works at the War Office and Chief Engineers of Commands. It will be his duty to see that there is no confusion, delay, or waste of effort, when work has to be handed over from one corps to another, or from Corps Engineers to the Works Directorate.

In addition to the above, the D.G.E.S. will have to plan and carry out, through his Works Directorate, any work needed in the L. of C. area for the impending operation, such as construction of camps, development of water supply, additional roads, in preparation for troop concentrations. Information regarding these works must come from the General Staff, either from the R.E. Section of the General Staff to the D.G.E.S. direct, or from C.G.S. to Q.M.G. as regards the wider aspects.

The presence of a R.E. Section in the General Staff will ensure that full emphasis is given to the time required for Engineer work, and the consequent need for early information to the Engineers regarding contemplated operations.

Possibly, in the above outline, I may have conveyed the impression that everything is to be done, thought of, and prepared, at G.H.Q., and that the attitude of Chief Engineers of armies and corps and C.R.E.s of divisions may be a purely static one. Nothing could be further from the intention of the *Field Service Regulations*. Engineer Commanders of every grade must help in trying to prepare for eventualities. I can only say from some considerable personal experience as the Senior General Staff Officer of a Division, Corps and Army in France, that the attitude of sitting quiet and waiting for orders from above was never one which characterized Engineer Commanders in the field. Indeed, as a harassed Staff Officer, I have often found myself wishing that it did.

That, gentlemen, concludes my review of the work of the Royal Engineers and the developments of its connection with the Quartermaster-General. Much of what I have said about the past is doubtless familiar to you; some of what I have said about the future may conflict with your personal views. For myself, I can only say that the preparation of this paper has brought home to me, in a way which nothing else could have done, the gradual development of the Royal Engineers from a small body of somewhat doctrinaire exponents of an exact science to a Corps whose motto, *Ubique*, expresses not only the widespread location of its technical employment, but also the predominant position of its officers in all the varied functions of an army.

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THE BRIDGE PROBLEM OF THE BRITISH ARMY.

Winning Essay for the Cooper's Hill War Memorial Prize, 1929, by CAPTAIN C. P. WORSFOLD, M.C., R.E.

WRITING an appreciation is the recognized method of solving a tactical or strategical problem. The bridge problem is alike in its complexity, so that it would seem appropriate to adopt the same method for its solution. This involves, firstly, defining the object to be achieved, then weighing the factors affecting the attainment of the object, and, finally, making a plan.

Definition of the Problem.

The object in this case is to organize, equip, and train, the British Army so that in war the passage of rivers may be effected with ease and speed. The commander of the whole, or any part of it, must not be hampered in his liberty of manœuvre, either by lack of means to cross any bridgable obstacle, or by an excessive train of bridging equipment. Finally, there must be an adequate provision for the maintenance of communications.

PRINCIPAL FACTORS BEARING ON THE PROBLEM.

Limitations of Finance.

In peace, finance is the most important factor in all problems of military organization. There is an ever-present urge for economy, which rules out frequent changes of equipment in large quantities, or additions to peace establishments. Developments in engineering, however, render equipment obsolete. Increased weights of military vehicles make heavier bridges necessary, and heavier equipment needs more men to handle it. The great mobility added by mechanization means that more rivers may have to be crossed in a given space of time and more equipment is, therefore, required.

Methods of meeting the need for economy.—On the other hand, manufacturing processes become ever more rapid, and at the same time, mobilization is a more leisurely affair, so that much equipment may be manufactured on the outbreak of war. Small peace establishments for engineer units can be rapidly expanded with partially-trained men from the engineering trades, organized as in the Supplementary Reserve. Lack of training may be compensated by standardizing and simplifying equipment, though standard designs must be kept up to date by continuous research and experimental work.

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If supply, on mobilization, is properly arranged, it may be possible to reduce the equipment held in peace to the amount required for training purposes. Desirable changes of pattern could then be introduced at small expense.

Role of the British Army.

Bridging requirements are affected to a great extent by the conditions under which the British Army may be expected to take the field. It is unfortunately impossible to prepare for all eventualities. All that can be done is to select the most probable and make provision for meeting that, at the same time planning the alterations required under other possible sets of conditions.

Most probable campaign.—From past history, the present international situation, and a study of the frontiers of the Empire, it may be deduced that the most probable employment of the British Army is in an undeveloped territory, against an enemy equipped with modern rifles, machine-guns, and, possibly, a considerable artillery. It is, however, conceivable that it might have to go to the rescue of a Dominion in defence of its territory, or to act as the advanced guard of the nation in arms in a European theatre of war.

If operations are to be conducted in undeveloped country, it follows that transportation facilities will be poor. Therefore, the amount of bridging equipment carried with field formations must be reduced to a minimum, though the fact that it may be more difficult to get equipment forward must be taken into account. The equipment and its transport must be robust, to stand the long distances over rough going, and every part must be easily portable. The effect of climate must be allowed for in determining the materials of which the equipment is made.

The possession of machine-guns and artillery by the probable enemy, renders a certain amount of assault bridging equipment essential, though perhaps not on the scale necessary in a " national " war.

The possible use of the British Army in support of a Dominion points to the desirability of using the same type of equipment throughout the Empire.

Tactical Considerations.

Time.—The most important tactical factor is time. The passage of a river must not delay a force longer than is absolutely necessary. The bridging equipment should, therefore, be devised so that bridges may be ready by the time the troops, or vehicles, which are to cross them, are needed on the other side. This naturally involves a series of different types of bridge to meet the needs of the various arms, and of the stages in the attack.

Location of equipment.—It is obviously essential that the bridging equipment, and the men to use it, should be on the spot when they

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are needed. Long intervals of time, however, frequently elapse between major bridging operations. It is an unsound policy to burden mobile formations with the impedimenta which they may need for the passage of the one important river in the theatre of war, though it may be many days' march away, if it can be sent forward from the rear when it is wanted. In principle, bridging material should be kept as far back as possible, consistent with its being available at the place and time when it is required.

The distance in rear at which it may be kept is a matter which can be calculated with reasonable accuracy from known data, such as the distance at which aircraft reconnaissance, or other means of intelligence, may be expected to reveal the presence and approximate width of a river, the time which the formation will take to march that distance, and the time required to get equipment forward. A substantial factor of safety must, of course, be allowed in such a calculation.

Maintenance of tactical integrity.—Another important tactical point is, that every commander must be permitted to keep his force intact. A cavalry division must not be compelled to leave its armoured cars behind for lack of bridging or rafting equipment, or an infantry division tanks which may have been allotted to it. Every detached force must be equipped to allow all parts of it to cross any bridgable obstacle that it may meet.

The assault on a river position.—An opposed river-crossing is a most difficult tactical operation. The usual process is, first of all, to get infantry across to form a bridgehead, under cover of darkness, smoke, or violent artillery bombardment ; secondly, to follow them up closely with their supporting weapons—mechanized machine-guns, anti-tank guns and close support artillery ; thirdly, to move forward part of the field artillery, and, finally, to send over the remainder of the force—reserves, transport and ancillary units.

The conditions imposed on the leading infantry make it necessary that their bridge should be of the simplest description, inconspicuous, very portable, not easily damaged by fire, and, above all, suited to rapid construction by unskilled men. It must be provided on a generous scale, to ensure that the enemy's fire shall be distributed over a large number of bridges. The present Kapok equipment seems to provide a complete solution to this problem for rivers of moderate width and current.

Bridge for infantry-supporting weapons.—The question of a bridge for the infantry-supporting weapons is much more difficult, and it is, perhaps, a little premature to suggest that a design should be attempted, seeing that the method of carriage of these weapons is far from being finally settled.

It is evident that they will have to follow the infantry very closely, and that, in consequence, their bridge may have to be launched under

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rifle and machine-gun fire. The ideal would be to have an equipment which could be constructed under cover and then towed down to the site by the vehicles to cross it, in the same way that the infantry carry their own Kapok assault bridge. There are many technical difficulties, however, in designing a simple, robust and cheap equipment to this specification. Owing to the steady increase in the weight of the vehicles involved, it is probable that a rafting arrangement will be the compromise, in spite of the time wasted and the inevitable exposure of men to bullets.

Passage of field artillery, etc.—The increased range of field artillery makes it unnecessary to move batteries across a river until the infantry have got some thousands of yards ahead. There should be ample time, therefore, to construct a medium or even a heavy bridge of pontoon equipment before batteries have to cross. This bridge can then be used for the remainder of the force.

Number of pontoon bridges needed by an infantry division.—Tactical considerations always govern the number of assault bridges, and frequently the number of pontoon bridges required for the passage of a river. It is necessary to bear this in mind when settling the scale of equipment. The normal needs of supply, and of the passage of troops and vehicles, can be met by two medium bridges on a divisional front, but tactical necessity frequently demands three or four crossings for medium and, in some cases, heavy loads.

Heavy bridge for an infantry division.—Although medium tanks are not included in the war establishment of an infantry division, it is reasonable to suppose that no advancing infantry division will be without a few of them. At least one heavy bridge is, therefore, likely to be needed by a division under normal circumstances.

Cavalry needs.—The cavalry are often detached to perform tasks in advance, or to the flank, of the main body. It is, therefore, fitting to consider their special requirements with regard to bridges.

One of the main advantages of the retention of the horseman, in these days of mechanization, is that he can swim across a river. There is, accordingly, no need to worry about his bridging needs. But in addition to mounted men, a cavalry division has armoured cars, and mechanized machine-guns, anti-tank guns, artillery and transport.

Armoured cars.—Armoured cars must range far and wide away from the main body of the division. Their tactical advantages are their extreme mobility, and their comparative inconspicuousness. These advantages would be entirely negatived if they had to be accompanied by vehicles carrying bridge equipment. If they cannot get forward with equipment carried on the car itself, they must use their mobility to find a way round. It should be possible to carry on the car itself a pair of light joists for crossing shell holes and trenches. It might

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be possible to add to them inflatable floats, and so make a rafting arrangement, but that is the most that can be expected.

Need for a light bridge.—The primary role of the mechanized machine-guns is defensive. They occupy positions on which the mounted squadrons can fall back. It is unlikely that the cavalry would be ordered to seize a bridgehead if the further bank were strongly held by enemy machine-gunners. It may, therefore, be supposed that bridging for the mechanized machine-guns, following the mounted squadrons at some distance, would not be exposed to enemy machine-gun fire. Ordinary pontoons might be used, but they are not well adapted to these "light" loads. Their use on the scale required by the tactical situation would involve a great waste of material. A special "light" bridge would be much better.

The opposed crossing of wide rivers.—Crossing wide rivers, in the face of opposition, presents particular problems. During the Great War, there were several instances of attempts to cross wide rivers being defeated with very heavy loss; the Turkish attempt on the Suez Canal; General Maude's attempts to cross the Tigris, etc. These instances demonstrated that the effect of machine-gun fire on men in open boats was devastating. The possibility of attaching armoured protection to pontoons might be worth consideration. Armoured "bellums" were successfully used by Townshend at Amara, and the armoured lighters, called "Beetles," used in the landing at Anzac, saved a lot of casualties. In particular cases it might be possible to adopt the original method employed by the American who escaped from Sing-Sing. He walked under water for several hundred yards, breathing through a tube attached to a float at one end, and at the other end to a face-piece. Such a method would give excellent protection from enemy bullets, and might be feasible if the current were not too strong.

The needs of an armoured force.—Bridging for the armoured force offers a very difficult problem. If the force is employed on an independent mission, it must have means to get across a river. Even if it succeeds in finding an intact bridge on its way out, there is the danger of the bridge being blown up behind it, and its retreat being cut off. Its wide radius of action might necessitate crossing several small rivers, and these rivers must be crossed quickly, if full advantage is to be obtained from its mobility. Rafting, though economical in material, is too slow. There is also the problem of crossing in the face of opposition. It is evident that, with the present equipment, it would be impossible to get a single vehicle across a river if the far bank were held by an enemy armed with machine-guns.

On the other hand, an independent mission is not necessarily the only, or even the normal, employment of an armoured force, according

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to present ideas. It will usually be employed with normal formations who will be responsible for meeting its bridging requirements. A special type of equipment for the armoured force would be an expensive luxury. The only alternative is to provide it with sufficient pontoon equipment to meet its probable needs, when it is ordered on an independent mission. There still, however, remains the question of getting across a river in the face of opposition. The solution to this may be the floating tank, or, at any rate, a means of rapidly attaching floats to a tank without exposing men to bullets, combined with a gear for crawling up and down the steep banks of streams. Or it may be possible to produce an "assault" bridge for the lightest tanks. It is a problem inviting research.

Technical Factors.

Need for an increased supply of bridging material.—Before the Great War, all the vehicles of a division could cross a lightly-built timber trestle bridge. In consequence, little time was wasted in improvising with materials found locally. The advent of the tank and the mechanization of transport have greatly increased bridge loads, and in consequence, improvisation with local materials has become too slow a process. It is, therefore, necessary, not only that an increased amount of portable equipment should accompany the expeditionary force, but also that there should be a plentiful supply of material for the semi-permanent bridging which replaces the portable equipment.

Design of floating bridge equipment.—It has already been argued that the design of equipment should be as simple as possible, and that it should be standardized. It is also desirable that it should be adaptable to as many different uses as possible. There are, however, definite technical limitations to the design of an equipment to suit greatly varying loads. The floating bridge pier is the chief stumbling-block. If it is sub-divided too much, the fastenings become unduly heavy, and the piers required for the greatest loads become difficult to handle in the water. It is apparent that every equipment can be designed to suit a range of loads of a reasonable degree. The determination of this range demands very careful consideration, both from technical and tactical points of view.

As regards the ranges of present equipment, the Kapok bridge is ideal for infantry in single file, adaptable for infantry in file, possible, though unsatisfactory for pack animals and for rafting light tanks, motor vans, and horsed vehicles. The next range, the pontoon equipment, is designed for medium loads, that is, the maximum loads of the infantry division as it appears in *War Establishments*. It is quite satisfactory as a heavy bridge to take medium tanks, and six-inch guns. It is clumsy and unsatisfactory as the light bridge needed by light tanks, field artillery, mechanized machine and

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anti-tank guns, cavalry transport, horsed vehicles, marching infantry etc.

A new intermediate floating bridge suggested.—The present equipment is the outcome of experience in the Great War, but great strides in mechanization have been made in the last ten years, and to-day, it seems that some intermediate floating bridge is called for. In its lightest form, it might take pack animals, infantry in file, and vehicles of the nature of the Carden-Loyd machine-gun carrier. In its heaviest form, it might be designed for armoured cars, 30-cwt. six-wheeled lorries, and field artillery drawn by tractors. It might be the normal cavalry divisional equipment, and also be given to the infantry division for the passage of the infantry supporting weapons in the attack. Possibly, it could be adapted to the needs of the armoured force for an assault equipment.

Passage of swift rivers and dry gaps.—The main bridge problem is the passage of the river for which a floating bridge can be used, but there are the subsidiary problems of crossing swiftly-flowing rivers, shallow dry gaps and deep ravines.

The passage of infantry across a swift river under fire is a most difficult operation. Probably the only solution will always be to choose some point of crossing where the current is sufficiently slow to permit the use of Kapok equipment. The light Inglis bridge was developed during the War for crossing distances up to about 120 feet in a clear span, but such an equipment would seem a luxury for the type of campaign which is our primary concern. Bridging for the infantry to assault across a ravine, or other dry gap, will so seldom be necessary that it is evidently not worth while providing a special portable equipment for the purpose.

Clear span bridges.—For vehicles the present trestle equipment has been evolved as the result of years of experiment, and seems entirely suitable for shallow rivers, and shallow dry gaps. For ravines up to 100 feet in width, the box girder, divided up into portable sections, has been devised. For longer spans, the only solution appears to be the suspension bridge, since the weight of girder bridges in proportion to the load they bear increases very rapidly after about 100-foot span.

The chief difficulty about suspension bridges, is in providing a sufficiently good anchorage for the cables in a short space of time. The possible use of rapid-setting cement should not be overlooked in this connection.

Equipment for crossing dry gaps.—As regards the carriage of equipment for dry gaps, there is always the possibility of the enemy cratering a road, blowing up a bridge over a railway, or a culvert, and so creating an unforeseen dry gap. This will usually be made in a place where a détour for vehicles is impracticable.

It is necessary that there should be some trestle and girder equip-

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ment well forward to meet this contingency. About thirty yards of medium trestle equipment, with, perhaps, sufficient box girders to take medium loads over a sixty-foot gap, might reasonably be allotted to an infantry division for this purpose. A cavalry division, with its superior mobility, should, as a rule, be able to avoid the necessity of bridging a dry gap. Moreover, it would seldom have the time to spare for the construction of girder bridges. As for trestle equipment, the cavalry will, in any case, need some for the shore bays of its pontoon bridge.

Semi-permanent bridging.—When time is not so pressing, economy comes to the fore. That is why it is necessary to arrange for the replacement of " equipment " bridges by bridges of cheaper and more permanent construction. It is not essential that the parts of these bridges should be very portable. The more they accord with ordinary civil engineering practice, the easier it will be to provide them in war. It is essential that time and labour should not be wasted through trying to improvise with unsuitable materials. Facilities of transportation have greatly increased in recent years, and there is to-day small reason why the engineer should not have an ample supply of stores sent up from the base when he cannot find suitable material locally.

Railway bridges.—There has been no appreciable change in the problem of constructing military railway bridges in the last thirty years. The experience of both the Great War and the South African War is available to determine the amount of stores which may be required, and the best organization of the transportation engineers for carrying out the work. Railway construction itself is not sufficiently fast to warrant the use of portable equipment, as in the case of road bridges. The chief directions in which improvements might be effected are in the use of portable power, and the application of recent new engineer materials, such as rapid-setting cement and alloy steels, to speed up work.

Transport.

Effect of motor transport for bridging equipment.—Motor transport can move two or three times the distance that a normal division can move in one day. The use of it for bridging equipment, therefore, makes it possible to keep the equipment with rearward formations, corps, or army, and send it up when it is needed. It is essential that the motor vehicles should be able to travel across country even when fully loaded, so that they may be brought as close as possible to the bridge sites. The recently-developed six-wheeled motor lorry seems to meet requirements in this respect.

Means of economizing in transport.—So much transport is locked up by keeping all the portable bridging equipment on wheels, that the question of whether transport should be provided for the whole of it is worth examination. Sometimes, for weeks or months on

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end, the equipment is not needed. As a rule, it is then dumped and the transport released for engineer work. This, however, does not justify the provision of more vehicles than are absolutely necessary. There is no doubt that all the pontoon and all the assault equipment might be required simultaneously, but that is only likely to be so when a large-scale attack on a river position is planned. It is probable that such an attack would take several days to prepare, during which the force would be halted. In consequence, a quantity of transport would be released which could be used for bringing up such bridging equipment as did not require special vehicles.

There remains the problem of moving the stores as the formation advances, when no surplus transport is available. In the division, the only solution seems to be to have everything on wheels. Most of the bridging equipment, however, can be located back in corps and army areas, where it should be feasible to keep it in parks near the railway. As the advance progresses, new parks could be established for corps by railing equipment from the base, the army taking over the corps parks, and in turn, handing on its equipment to an advanced base. This method might be applied to all equipment other than that requiring special vehicles. The latter must, of necessity, be entirely on wheels.

Engineer Mechanization.

The mechanization of military engineers is being tried out in two directions, namely, the supply of power in a portable form to speed up engineer operations, and the carriage of engineer personnel and tools in motor transport.

Use of power in a portable form for bridging.—The civil engineer to-day makes a very wide use of portable power tools, such as pneumatic drills, picks, shovels, saws, riveters, hoists, wood borers, etc. Many of these are adaptable to military needs. For bridging, power might be applied to lifting and hauling, pile-driving, timber-cutting and boring, metal-cutting, drilling, riveting, concrete-mixing, etc. Provided, therefore, that experiment leads to the conclusion that these tools can stand the very rough usage, and the unskilled attention which they will inevitably get in the field, it follows that the saving of time justifies their forming part of engineer equipment.

Carriage of engineers in motor transport.—There are many arguments in favour of the carriage of engineers in mechanical transport. From the point of view of bridging, it should have an important influence in speeding up work. The control of the engineers could be centralized, thus giving increased facilities for the co-ordination which is necessary in bridging operations. Concentration of engineers for a particular bridging task would be easier to achieve. It would be possible to leap-frog engineer units, so that when once a unit had been entrusted with the construction of a certain bridge, it would be

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unnecessary to move it until its task were complete. This would involve the elimination of differences between units for constructional engineering, the field company, and the army troops company, but would lead to a great economy in the use of engineer personnel. If units were leap-frogged it should be possible to manage with less motor vehicles than would be required to carry the entire personnel of all the companies. This would reduce the heavy cost which is the chief obstacle to the adoption of the scheme.

Character of the Terrain.

Need for an engineer study of the theatre of war.—Equipment must, from its nature, be suited to average conditions, since it must be designed long before the commencement of a campaign. The material and plant sent out for semi-permanent bridging should, however, be suited to the conditions in the theatre of war, and the local resources, if any. This demands, in peace, a close study of the available intelligence respecting districts in which operations may take place, both as regards the rivers, and the possible local supplies of timber, steel, stone, cement, etc. It is not sufficient to wait until the expeditionary force has arrived, and then to send out what is demanded. The material will always arrive too late.

Training.

Simplicity in equipment.—The principle of economy of force makes it undesirable to have special units exclusively allotted to bridge building. Bridging must, therefore, have a part in the training of every engineer. Since it is only a part, it follows that the equipment must be made as simple as possible, and training must be confined to essentials.

Principal points in unit training.—The saving of time in bridging is the chief matter from the tactical point of view. Tactical efficiency is more important than technical efficiency, since it is vital to the success of operations. Moreover, technical efficiency can be acquired by practice during the campaign. Training should, therefore, be directed towards the saving of time. This involves paying most attention to drill, watermanship, and the handling of heavy weights. Drill, because it quickens all operations, particularly when it may be necessary to undertake them in the dark. Watermanship, because pontoons demand good handling in the water, and bad handling is a very fruitful cause of delay. Practice with heavy weights speeds up the construction of girder bridges.

Take advantage of India for collective training in bridging.—Collective training in Great Britain offers little opportunity for large-scale bridging operations, owing to the lack of important rivers in training areas. In India, however, there are much better facilities, and the large part of the British Army stationed in that country might be specially exercised in them.

Things to practise during collective training.—Collective training is

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intended for the purpose of practising things which require the co-operation of the different arms, and of the staffs of formations. From the bridging point of view, this should include the organization of bridging reconnaissance, co-operation of engineers and infantry in the assault on a river position, exercise of the engineer headquarters and the staffs of formations in planning bridging operations, and the organization for ensuring that the bridging equipment is at hand when it is needed.

THE PLAN.

Having discussed the main factors bearing on the bridge problem, it is now necessary to frame a plan for its solution. It will be convenient to outline the plan under the headings of equipment, organization, training, research, and preparation for war.

Equipment.

Cavalry division equipment.—Taking the various arms in the order in which they may be expected to arrive at the point to be bridged, the first formation to be considered is the cavalry division.

It is reasonable to suppose that, with aircraft available, the commander-in-chief, before dispatching a cavalry division on a detached mission, will be aware of all major rivers (say, over forty yards average width), which it may be called upon to cross. For these major rivers, or if he attaches medium tanks to the cavalry, he can allot additional equipment from army reserves.

It is, therefore, recommended that the permanent provision with the cavalry division should be sufficient for forty yards of a bridge suitable for all its vehicles, and a " tactical " bridge of similar length for its mechanized machine-guns, and anti-tank guns.

Thus the cavalry division bridging equipment would be :—

(1) Present pontoon equipment, including trestles for shore bays : 40 yards medium, 40 yards light.

or preferably the same quantity of :—

A new " intermediate " floating bridge equipment which, in its heaviest arrangement, would take all cavalry divisional loads, and, in its lightest, mechanized machine-guns.

(2) For armoured cars : light joists and possibly inflatable floats which could be carried on the cars.

Infantry division equipment.—The next consideration is the infantry division. This is a slow-moving formation, and there will always be such ample warning of the proximity of the smallest stream, that equipment can be sent up from corps.

For training purposes and emergency use it is necessary to provide the infantry with some assault bridging equipment, both for men on

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foot and also for the supporting weapons, machine-guns, anti-tank guns, and close-support artillery.

It is suggested that sufficient material for an opposed crossing of a sixty-foot stream on a battalion front would meet the case. An average amount to allow would be eight bridges for infantry and four for the supporting weapons.

From this and previous conclusions, the equipment of the infantry division might therefore be as follows :—

(1) Kapok equipment : 160 yards.
(2) New " intermediate " equipment in light arrangement, as for cavalry : 80 yards.
(3) Present trestle equipment : 30 yards for medium loads.
(4) Box-girder equipment : 60-foot span for medium loads.

Armoured force equipment.—To the armoured force, no permanent allotment of the present pontoon equipment should be made. Some means must be found for getting its lightest tanks across a river under machine-gun and rifle fire, either by adapting the proposed intermediate equipment, if practicable, or by attaching floats, a propeller and crawling-out gear to the tanks themselves.

Corps equipment.—The corps must carry sufficient bridging equipment to meet the needs of its infantry divisions, in the passage of such rivers as may have to be crossed with insufficient notice to send forward equipment from the army. Army aeroplane reconnaissance may, at least, be expected to reveal any river over twenty yards in width, a hundred miles ahead of the leading infantry division. A hundred miles is seven days' march, so that there should be ample time to get bridging equipment from army engineer parks for all rivers over twenty yards wide.

On this basis, it is recommended that the corps should be provided with sufficient assault and pontoon equipment to enable two infantry divisions, accompanied by tanks, to get across a river twenty yards wide. The amounts necessary for this purpose would be as follows :—

(1) Kapok equipment for six battalions : 960 yards.
(2) New " intermediate " equipment in light arrangement : 480 yards.
(3) Present pontoon equipment, sufficient for one heavy and two medium bridges per division (allowing one medium for tactical purposes) : 56 yards heavy, 112 yards medium.

The corps also requires box girders, tube piers, steel cubes, joists, decking and other bridging stores, to enable its engineers to release the portable equipment for further work ahead. These might be provided on the basis of one complete replacement of the pontoon equipment, further replacements being met from army or base reserves.

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Transport should be provided for all portable equipment requiring special vehicles, such as pontoons, for fifty per cent. of the assault equipment, and perhaps twenty per cent. of the remainder.

Army equipment.—The army should hold enough bridging equipment to assist corps over all rivers of the normal width to be met with in the theatre of war. Exceptionally wide rivers, which might be taken as those more than a hundred yards wide in the vicinity of the point of passage, are usually well known. The possibility of having to cross them can be foreseen in time to forward bridging material from the base.

The army may also be called upon to supplement the pontoon equipment of a cavalry division, or to provide equipment for an armoured force to enable it to execute an independent role. It must have girders, and other bridging stores for semi-permanent work to release the portable equipment for further use.

On this basis, it is recommended that the army should be equipped as follows :—

(1) Sufficient "Kapok" bridge to supplement the corps equipment for the passage of a river up to 100 yards wide.
(2) New intermediate equipment on a similar scale.
(3) Present pontoon equipment. Sufficient to supplement corps and cavalry divisional equipment for the passage of a river 100 yards wide, and to provide, in addition, at least two heavy rafts for the armoured force.
(4) Box-girder bridges, tube piers, piles, steel cubes, steel joists, decking, cement, fastenings, etc., for one complete replacement of the corps portable equipment.

Transport for army equipment.—As in the case of corps, transport need not be provided for all this equipment. The scale of transport might be :—

(1) All pontoon equipment.
(2) 30 per cent. assault equipment.
(3) 10 per cent. remainder of bridging material.

Base reserves of equipment and stores.—Finally, it is necessary to consider what should be kept at the base. There are three demands which have to be met, viz. :—

(1) The replacement of wastage in portable equipment.
(2) The extra portable equipment required for an exceptionally wide river.
(3) The need for large quantities of semi-permanent bridging material during an advance to free the portable equipment for further work ahead.

The replacement of wastage can be assessed from experience in past campaigns.

The amount allowed for the exceptionally wide river must be

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settled for the particular theatre of war from intelligence collected in peace. An arbitrary width of a quarter of a mile might be taken as the basis of provision plans in peace, the amount actually dispatched with the expeditionary force being varied as required.

The base reserve of steel bridges and of bridging stores also depends very greatly on the circumstances of the campaign, such as the distance from home, character of the country, local resources, etc. The lack of any determinate basis should not be allowed to result in the dispatch of the expeditionary force without any of these stores. The requirements for the most probable theatre of war should be worked out, and arrangements made in peace for provision to meet them. If some other war should break out, the necessary adjustments to supply could be made on mobilization.

Organization.

Centralizing the control of engineers.—Bridging is to-day the most important function of the military engineer. It is, therefore, reasonable that engineer organization should primarily depend on what is most suitable from the bridging point of view. Efficiency in bridging operations demands close technical control, concentration of engineers, co-ordination in depth by an engineer commander, and an assured supply of stores, transport and labour. Given the mechanization of engineers, these desiderata can best be achieved by centralizing engineer control. This might be done by withdrawing the permanent allotment of engineers to the infantry division, and forming them into a brigade under the chief engineer of the corps. In this way, the services of the engineers could be utilized with maximum efficiency. It does not mean that the leading divisions would be deprived of engineers, and their commanders of engineer advice, any more than that they would not be allotted tanks or heavy artillery if they needed the latter. But it does mean that the chief engineer of the corps would be able to concentrate the whole engineering force of the corps on the execution of important tasks, such as bridging. He would also have full control of the consumption of the stores, which it is his function to provide, and would be in a stronger position to get the transport and labour needed.

It necessarily involves the provision of mechanical transport for the carriage of engineer personnel, though not for more than about half, since work can be organized so that units are leap-frogged forward. This transport will often be available to meet the large demands of engineer work for which little allowance is made in present *War Establishments*.

Reconnaissance and liaison arrangements.—From the bridging aspect, if engineers are concentrated under corps control, it is essential to make special provision in their organization for reconnaissance, for liaison with leading formations, and for engineer advice to the commanders of those formations.

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Reconnaissance can best be carried out by small parties of an officer and one or two other ranks, equipped with motor-cycles, or perhaps a small cross-country motor-car. These parties must accompany leading units and have means for the rapid dispatch of information to the rear.

Engineer advice is best given by the engineer commander responsible for carrying out the work. Engineer commanders must, therefore, expect to be normally at headquarters of formations and often detached from their units. Their presence at headquarters also solves the problem of liaison, but it is necessary that recognition should be made of the need for the frequent detachment of the commander, with a small liaison group, when framing establishments.

Transport arrangements for equipment.—If there are no engineers permanently allotted to the division the carriage of the divisional bridge equipment might devolve on the divisional R.A.S.C., a few sappers being attached for maintenance purposes.

Corps and army equipment should, however, be kept under engineer control, so that there may be transport available for other engineer work. Bridging parks might form part of the centralized R.E. organization of those formations. As previously stated, it should be entirely unnecessary to keep the whole of the equipment on wheels, a hundred per cent. transport being provided only for such equipment as requires special vehicles, for instance, pontoons.

Training.

Features of unit training.—It has been deduced that the three principal features of peacetime individual and unit training in bridging should be drill, watermanship and the handling of heavy weights.

Drill in the use of equipment is the first essential, since it will quicken bridging operations at their most critical stage. It must be taught not only to the engineers, in the use of pontoon equipment, but more essentially to the infantry in the use of their assault equipment, since they may be called upon to work under more severe conditions of fire and darkness. Drill in the use of Kapok equipment, and of the proposed intermediate equipment, must, therefore, form a conspicuous part of the training of every infantry unit.

Watermanship is entirely a matter of practice in handling heavy boats and pontoons. It is impossible to make sappers into efficient watermen, unless a great deal of time is devoted to practice. The annual bridging camp is not long enough to provide sufficient time, so that it is necessary to seize every opportunity throughout the year of training sappers in the handling of boats.

Dealing with heavy weights, launching girders, use of derricks, etc., are matters in which engineer officers and N.C.O.s require constant exercise, both in practice and theory. They can be practised at the unit's station all the year round, as well as at the annual bridging camp, since they do not necessitate a wet gap.

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Special features for collective training.—The matters to which special attention should be directed in collective training, are as follows :—

(1) The organization of bridging reconnaisance.

(2) The exercise of the staff and the engineer headquarters in planning bridging operations.

(3) Movement forward of bridging equipment from the engineer parks of rearward formations.

(4) Co-operation of the engineers and other arms in forcing a river-crossing.

Full advantage should be taken of the more favourable conditions in India for collective training in bridging operations.

Research.

Problems inviting research.—The principal problems which invite research and experiment at the present time, are :—

(1) The evolution of a new floating bridge equipment to provide :

(*a*) In its heavy arrangement for the passage of the heaviest cavalry divisional load.

(*b*) In its light arrangement for pack transport, mechanized machine-guns, anti-tank guns and close-support artillery.

(*c*) Possibly an assault bridge for the lightest armoured fighting vehicles in the armoured force.

(2) Any alternative means of getting light tanks across a river under machine-gun fire, whether by raft, or by detachable floats, combined with propelling machinery and crawling-out gear.

(3) The provision of light joists to enable armoured cars to cross shell holes, trenches, etc., and possibly inflatable floats, which could be carried on the car and used for the crossing of rivers.

(4) The protection of infantry from machine-gun fire in crossing wide rivers.

(5) The application of power to military bridging. Power might be applied to lifting, hauling, launching pontoons, pile-driving, concrete-mixing, timber-cutting and boring, metal-cutting, drilling, riveting, etc.

(6) The use of rapid-setting cement in military bridging.

Direction of research.—The control of research has been efficiently conducted for a number of years by a board of technical officers, the R.E. Board. If any improvement is possible, it is in the method of initiating research. The direction of research policy is in the hands of the General Staff, but in directing policy, the Staff must be kept

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informed of technical possibilities. Better liaison might be achieved by making a senior member of the General Staff at the War Office president of the Board, the senior Technical Officer retaining his present co-ordinating duties, and ranking as deputy-president.

Preparation for War.

Arrangements for supply on mobilization.—In order to save expense and to facilitate the adoption of the latest improvements, it is desirable to provide, in peace, only sufficient equipment to admit of peace training, leaving as much as possible to be produced on mobilization. Although mobilization is to-day a leisurely proceeding, there is not sufficient time to improvise supply arrangements. It is essential that these arrangements should be worked out in peace. The preparations might include, first of all, a schedule of articles required to complete the bridging equipment of units of the expeditionary force, and to stock the engineer bridging parks, showing the time by which they will be needed; secondly, a list of the contractors who can supply the stores, with details of their manufacturing capacity and usual stocks; thirdly, the dovetailing of these lists together and the preparation of draft orders on contractors, designs, specifications, and possibly jigs, so that manufacture may be as rapid as possible. The adoption of commercial sizes and designs, wherever possible, without serious detriment to military requirements, would greatly facilitate supply. The responsibility for the preparation of such a mobilization scheme should, of course, rest with the War Office branches responsible for the provision of engineer equipment and stores.

Preparation of an engineer plan in peace.—It has already been suggested that an engineer study of the conditions in the most probable theatre of war, is needed to ensure that adequate and suitable bridging material accompanies the force sent. This study is only part of the larger matter of framing an engineer plan to foresee and provide for all engineer arrangements required during the advance of the expeditionary force from its base until contact is gained with the enemy. The need for such a plan is obvious.

Unfortunately, there is no engineer co-ordinating authority, such as an engineer-in-chief, to whom the framing of this engineer plan could be entrusted. The next best solution would seem to be to give the task to a War Office committee, composed of representatives of the engineer personnel, provision and research authorities, and of the part of the General Staff concerned with operations and intelligence, under the chairmanship of the senior engineer officer.

Besides working out the engineer plan for the most probable war, such a committee might be required to examine the modification necessary for a national war. It might also be made responsible for recommending arrangements for ensuring the Imperial standardization of bridging equipments.

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"FORTIFICATIONS IN 1914–18."

"One does not fortify by systems but by good sense and experience."—*Vauban.*

By BT. MAJOR G. I. THOMAS, D.S.O., M.C., *p.s.c.*, R.A.

I. LIÉGE AND VERDUN.

General.

It is convenient to deal generally with Liége and Verdun under the same heading, for, as we shall see later, they both differed materially from the German fortifications at Metz, and both belonged in essentials to the same school. The systems of defence advocated by all writers on the subject during the years subsequent to the Franco-Prussian War of 1870 were, in nearly every case, "guided by the three following considerations: that works should be as little visible as possible; that cement concrete cannot be seriously injured by high-angle fire, either with shells or obus-torpilles; that guns in cupolas will out-last a great deal of hammering, even if they may at last succumb."* The fortifications of the frontiers of Belgium and France were overhauled and reconstructed commencing about 1880–88 in accordance with the theories advocated by General Brialmont,† one of whose forts has been described as follows:—‡

"It is triangular in form, as being easy to adapt to the ground and having the minimum number of sides to be flanked. The ditch had a counter-arched counterscarp, 16 feet high, of a very solid construction to resist obus-torpilles, the arches being 8 feet 6 inches thick in cement concrete. The exterior slope of the parapet at 2/3 forms the escarp. The parapet is about 26 feet thick, arranged for musketry only, except at the angles, where are cupolas for machine-guns.

"In the centre of the fort is a large mass of cement concrete, hollowed out underneath into magazines and stores, illuminated by electric light and artificially ventilated. This concrete mass carries, at its highest point, a look-out place and an electric light.

"In front of this is a large cupola for two 15-cm. (5·9-in.) guns. This has a command of 3 feet 3 inches over the outer parapet. To right and to left of this, at the same level, are two cupolas for one 12-cm. (4·7-in.) gun each, and in front of the guns there are three

* *Text Book of Fortification and Military Engineering*, Pt. II, 1893, p. 164.

† Lieut.-General Henri Alexis Brialmont, 1821–1903, *Fortification du Temps Présent* and other works.

‡ See * *Ibid.*, p. 165.

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cupolas each for one 21-cm. (8·24-in.) rifled mortar. These are 3 feet 3 inches below the outer parapet, and, therefore, hidden from the enemy. The gorge,* both escarp and counterscarp, is arranged for casemates for men and stores. The only way for the infantry to get to the outer parapets is by the stairs in rear of the concrete mass."

Forts of this description were usually sited on what were considered in those days to be good artillery positions, and so we find them on the top of hills commanding with direct fire the country in the immediate vicinity. The whole work is flat and does not usually break the contour of the hill when seen from a distance, whilst it was camouflaged from ground observation by growing turf over the white concrete, planting small trees, laurel bushes, etc.

Liége.†

The defences of Liége, commenced in 1888, consisted of twelve detached forts, half large and half small, and equally divided between the two banks of the Meuse. They formed a girdle around the town on a perimeter some 30 miles in extent, at an average distance of about 4 miles. On the east, towards Aix-la-Chapelle, and on the north they were about 2½ miles apart, whilst on the south the interval was bigger and there were three on a front of 7½ miles. All the forts were the recognized Brialmont type, though four of them were in the shape of a quadrangle, with the addition of traditor‡ guns in cupolas for the defence of the glacis to the front and flanks, and in casemates in the counterscarp for firing along the ditch. In 1914, the armament consisted of 15-cm. (5·9-in.) and 12-cm. (4·7-in.) guns, and 21-cm. (8·24-in.) howitzers mounted in cupolas. The guns were in twin turrets (except in the case of the 12-cm. in the small forts), but the howitzers were single cupolas, two in the large and one in the small forts. The traditor guns were 5·7-cm. (2·3-in.), the number varying.

All the cupolas were without exception disappearing, and no doubt their role is well put in the following quotation from the *Encyclopædia Britannica* of that time: § "Before quitting the subject it may be well to offer a few remarks on the employment of cupolas or turrets in land defences. Either of these forms of iron construction may be advantageously employed in advanced positions where it is necessary to retain guns until the very last—such as the salients of ravelins and in the angles of fronts of fortifications; also in points which are commanded from heights in their vicinity. As these constructions are indestructible by the direct fire of siege guns, and are absolutely safe from enfilade or reverse fire, they confer very

* *i.e.*, the ditch on the side farthest from the enemy.

† For much of the detail the author is indebted to *La Bataille de Liége*, by Colonel A. de Schryver.

‡ *i.e.*, quick firing guns for close defence.

§ 1879 edition reprinted 1898.

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great advantages upon the defence. They should mount heavier guns than can be brought against them; . . . ; and, at any period of the attack, they can meet its artillery with heavier metal." In 1909, the Engineer Staff of the Austrian Army only refers to a siege train "including howitzers of at least 10½-in. calibre,"* whilst our own regulations in 1910 only gave details for the construction of a siege platform up to the 9·45-inch B.L. howitzer as "heavier pieces . . . do not yet form part of the service siege equipment."† If the Belgians had had the least idea of the size and weight of the shells with which the Germans were going to bombard them we may be certain that they would have caused "the said bulwark before the said Milk Gate to be made so massy that it be not bateable."‡

Each fort was provided with armoured look-out posts, which, of course, only gave a direct view over the immediate countryside up to 1,000 to 1,500 yards, and also on to the tops of the more distant ridges. But the nature of the country implies a great deal of dead ground which it would be useless to search even with howitzers if there is no proper observation, and the Belgians only possessed a very few. To assist in repelling assaults by night, searchlights were installed in all forts in disappearing armoured cupolas.

The ditch round the forts was not very deep, about 17 feet, so that the entrance to the rear was down a gradual slope and never by a bridge. In some cases an infantry trench was dug on mobilization on the top of the counterscarp, to which it seems very doubtful if there were any underground passages. There were no machine-guns, either in cupolas or mobile. It had originally been the intention to raise one machine-gun company with each of the Fortress Reserve Regiments of Infantry which comprised the actual garrison, but, when it came to the point, this could not be done owing to lack of equipment. The living quarters were quite comfortable and well up to the standard of any continental barrack-room. They were lit by electric light, there seems to have been some form of central heating, whilst ventilation was partly natural and partly artificial with armoured ventilators on the rampart. Passages were narrow, but quite large enough.

What did Liége achieve in 1914?

Liége lies on the banks of the Meuse, at its confluence with the Ourthe, absolutely in a hole, completely surrounded by hills which rise abruptly from the main part of the town itself. It is an important industrial centre. Its population undoubtedly increased to an enormous extent in the 24 odd years before August, 1914. It is

* Para. 9, *Permanent Fortification for the Imperial Mily. Training Ests. and for the instruction of officers of all arms of the Austro-Hungarian Army*, by Major Moritz Ritter von Brunner.

† Para. 27, *Military Engineering*, Pt. II, 1910.

‡ Nichols' *Chronicle of Calais*, 1540, edited for the Camden Society, London, 1846.

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difficult to say whether the Commandant ever had any authority over what buildings were or were not allowed to be constructed in the immediate vicinity of the fortified zone. Certain it is that in 1914, as it is at the present day, houses existed everywhere right up to and around the very forts. Clearing a field of fire was attempted, but was from the first a hopeless task. When the Germans attacked, a front of about 4 miles facing Aix-la Chapelle, between Fort Fleron (then as now the most important) and Fort Barchon, was alone even reasonably clear, whilst in the wooded area to the south of Liége all efforts were given up as useless. In general, the country between and in front of the perimeter of forts is undulating, close and wooded. No doubt partly to overcome the difficulties due to the country, the agglomeration of buildings, and the limited view from the forts themselves, the defence scheme allowed for the manning of O.P.s in church towers, etc., at anything up to 2 miles in front of the perimeter. These were given 1 company of infantry for local protection, but, even so, they were right out in front of the main line of infantry redoubts, which were themselves sited abreast of and actually in the intervals between the forts. These redoubts seem to have been constructed mainly to cover the roads and tracks, but there is such a lot of dead ground that it was impossible in the time available to build sufficient to cover everything or even to make them mutually supporting. Barbed wire entanglements were everywhere very elementary. There was not enough wire, and the necessary transport did not exist to convey pickets, etc., out from the town. The mobile batteries intended to cover the redoubts in the intervals did not get into action in time and took no part in the defence.

The German plan for the capture of Liége was the work of Ludendorff and was bold and simple. It was carried out by General von Emmich with six columns of all arms, assisted by the Cavalry Corps of General von der Marwitz. Briefly, each column was ordered to detach parties to mop up the forward O.P.s, blind the searchlights, and contain the forts, whilst the main bodies forced their way through the intervals and seized the Meuse bridges and the town itself. This, with initial vicissitudes, was accomplished successfully, no doubt largely the result of the withdrawal by the Belgians of their 3rd Division, which they were afraid might be surrounded. Having thus isolated the forts, the Germans proceeded to subject each fort in turn to a violent bombardment, in which 42-cm. (16·8-in.) howitzers took part, directed from the air with aeroplanes and a Zeppelin.

Shortage of money had prevented the Belgians from constructing a permanent work covering the ford at Lixhe, the point at which the Germans crossed the Meuse. Whether economy was also responsible for the poor quality of the concrete used in the forts cannot be said, the fact remains that 22 cupolas out of 56 were put permanently out of action. German cavalry crossed the frontier on 4th August, the

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town and citadel of Liége was captured on 7th August, the last fort fell on 16th August.

The Belgians have always maintained that their defence of Liége gained three or four days for the Allies. On the other hand, the German "Schlieffen" plan for the invasion of France placed their armies on the line Thionville–Sédan–Mons on the 22nd day of mobilization (*i.e.*, 23rd August), and that is actually just about where they were on that date.* Be this as it may—consider for one instant the plight of the Liége forts. Manned entirely by reservists, isolated by the withdrawal of the 3rd Division from the field works, surrounded where they were never constructed for all-round defence, cut off by the fall of Liége town from all chance of obtaining ammunition or supplies, the armament blinded by the loss of the forward O.P.s and impotent against shell fire of a size and intensity never before dreamt of, with men going mad from the detonations and suffocating from the H.E. fumes—who will cavil at their white flags? In Fort Loncin, to which the Belgian Commandant, General Leman, had retired, the last act of the drama came when a 42-cm. shell penetrated the superstructure and blew up the magazine. This fort is now a museum and a meeting place for a club of the remnants of the defenders in memory of their oath to die together in defence of their country—300 Belgians are buried amongst the debris. A club of the survivors of such an oath may to the cynic sound humorous—let him go and see the place—it must have been a terrific explosion which blew gun turrets into the air to descend upside down, and filled the centre with enormous blocks of concrete refuse across which stumbled the wounded and semi-conscious Commandant.

Verdun.†

Verdun has always been fortified since the days of the Romans, and, in the centuries since, it has frequently been besieged. About 1880, the French started to reconstitute the defences into the form which they now have; for the forts of Verdun on the north, joined to Toul on the south, formed the defended area of "les Côtes de Meuse," which was an integral part of the frontier protection of France as planned a few years previously by General Séré de Rivières. Between that date and 1914, they spent over the whole country about 16 million sterling—Fort Douaumont is said to have cost £240,000. When the war broke out Verdun was protected by a ring of forts, sited in depth, on a circle round the town at a maximum radius of some 8 miles. They were all Brialmont type, but considerably strengthened and improved. The actual trace varied with the site, as at Liége; thus Fort Vaux was quadrangular, the smaller

* See footnote, p. 33 *Official History Milty. Operations, France and Belgium*, 1914.

† For much of the detail the author is indebted to an article on "Fortifications Françaises et Allemandes," by Colonel R. Normand, which appeared in *La Revue Militaire* in May and June, 1925.

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forts triangular. Constructed in the first instance of brick, the most important were later rebuilt with concrete, *e.g.*, Vaux and Douaumont; Fort Tavenne and many others were still brick in 1916.

The armament consisted of 155-mm. long guns (6·2-in.) and shortened 75-mm., the latter sited for use as traditor guns and for the defence of the intervals for which, in addition, intermediate works were constructed. All guns were in disappearing cupolas, protected with 30 cm. (12 in.) of armoured plate. The country around Verdun is comparatively open and a far better view is obtained from the forts than is the case at Liége, furthermore the town itself is small and there was, and is, no tendency at all for buildings to spread out into the fortified zone. The gun turrets were placed in the central rampart or on the counterscarp, which in this case had a ditch in the glacis, and were connected to the centre of the fort by underground passages. Complete reliance was not, however, placed in the guns of the forts, which were not very numerous, but the intention was to provide the main artillery defence from mobile batteries, fed by narrow-gauge railways. There were armour plated O.P.s and disappearing twin machine-gun turrets, but no searchlights. The ditch was very deep, and in some cases (as at Tavenne) entrance was effected by a bridge.

Ventilation was natural, and was assisted by the passage in the main works being wide and very high, whilst the barrack rooms themselves were lofty. There was no electric light, even the gun turrets were controlled in action at night by lanterns, and the washing, etc., arrangements for the garrison were very primitive and uncomfortable. All the contrivances for the comfort of the troops, of which traces can still be seen in Douaumont, sleeping bunks, washhouses, the canteen, operating theatre, electric light operated from a Diesel engine-room, were all installed after its capture by the Germans.

The Verdun Forts during the War.

The plans drawn up by General Séré de Rivières in 1874 had provided France with several lines of forts which covered Paris very effectively towards the north and north-east. In the succeeding years the results of the general trend of policy had been to "declassify" all forts on the northern frontier, *i.e.*, north of the Verdun area—for example, Lille was declared an open town in 1914.

In August, 1915, the French General Staff,* influenced by the rapidity with which the forts of Liége, Namur, Maubeuge, Warsaw, etc., had succumbed, decided that fortifications of such a nature had no further role in modern war, and that their resources in guns

* See p. 220, *Les Armées Françaises dans la Grande Guerre*, Book III, Part 2.

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and garrison should be released for use with the field army, from which alone a decision could be expected. The Territorial Divisions which formed the garrisons were therefore sent elsewhere, and the heavy and field guns were removed. For the September, 1915, offensive in Champagne, eighty 75-mm. guns and some 100,000 shells were taken from the Verdun forts alone.

The Germans opened their big offensive against Verdun on 21st February, 1916. Fort Douaumont, which up till then had been in the third trench line, perhaps 3 miles from the front line, and was only held by a small maintenance party, was captured by surprise on 25th February. Fort Vaux, deprived of its 75-mm. guns for flanking fire, could not assist Douaumont, and on the 8th March was powerless to prevent an attack on the Bois de la Cailette by seven German battalions, who assembled under its very nose in a hollow, to command which its now empty casemates had been built.

On 12th March, 1916, General Petain brought the forts once more into the picture. He let it be known that experience showed that forts were not the shell traps they were reputed to be. In fact, they had shown themselves very largely shell-proof, and far better organized for defence than hastily constructed field entrenchments. He ordered that they should be re-armed at once, the turrets put in proper repair, fresh garrisons detailed, and that they should take their place as part of the general defences of Verdun, to which end the demolition charges placed in all the turrets, etc., were to be withdrawn. Thereafter the forts were used consistently and considerably strengthened. Underground M.G. emplacements with tunnels leading to them were built in the glacis—piles of chalk, etc., were placed to thicken the protection over the passages leading to the counterscarp works—underground chambers were constructed at a depth of 60 to 70 feet—long tunnelled galleries, often 200 to 300 yards long, and in which a trench tramway line was laid, provided a safe entrance and exit to the forts—whilst the water supply was assured by wells. Everywhere where it was possible to replace the guns, the turrets remained in action throughout the rest of the War, and the forts themselves proved invaluable as bomb-proof shelters where front line and reserve troops could get rest and hot meals. The effect of the German shells of all calibres is a fine tribute to the work of the French Engineers. Douaumont, where the whole rampart and environs is pock-marked with craters, is the only fort that actually let a shell into the main superstructure. Here one French 400-mm. (16-in.) shell came in through the side and blew up a German grenade dump and many men—and in addition a German 420-mm. (16·8-in.) came in through the roof of the passage at the point where the thickness of the overhead concrete was reduced from 5 yards to 2, and destroyed a barrack room and a company of

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French infantry. Some of the weaker observation posts and machine-gun turrets were wrecked, but not one of the disappearing gun turrets was ever put permanently out of action, a statement which is not qualified by the case of the cupola in Fort Vaux which blew up owing to a German shell detonating the demolition charge which had at one time, in common with all the turrets, been placed inside it by the French.

The action at Verdun was of quite a different nature to that at Liége. The circle of forts was never surrounded, the forts were never isolated, only four, *i.e.*, Douaumont, Vaux (both without guns), Souville, Tavennes (both with guns), were ever in or really near the front line. The intervals were elaborately organized with field entrenchments held by the pick of the French Army, supported by a mass of skilfully led mobile artillery fully provided with aeroplane and balloon observation. We do not in any way belittle the extremely gallant defence of Verdun by the French if we remain unconvinced that its success was due to the forts, and reserve for the moment our decision as to whether the design of General Brialmont adequately fulfils all the requirements of permanent fortifications in modern war.

II. METZ.

The Germans started to overhaul the defences of their Western frontier soon after 1891, when von Schlieffen became Chief of the Staff. The system which they adopted, known as "Dispersed points d'appui," was radically different to that employed previously by other nations, and has been well summed up by Major Brunner.* He says:—

"There are still those who say that the modern forts with their active means of defence crowded close together form a very good target for the enemy, in spite of their small dimensions. They contend that the small width of the target lends itself to concentrated fire, and that the various positions, the flanking galleries, close range parapet, gorge buildings and the long range position, lying as they do one behind the other, all come within the danger zone of heavy howitzer and mortar fire.

"Thus, if the fire is directed at the cupolas of the long range position, shots which fall short are likely to damage the flanking galleries, while shots which are over the target may injure the gorge buildings.

"Several proposals to overcome this difficulty have been made. Some advocate the dispersion of all the component parts of the fort, others. . . . The first arrangement may be described as a system of 'Dispersed points d'appui' . . .

* p. 62, *Permanent Fortifications*, by Moritz von Brunner, 1910 (quoted before).

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" The advantages of this system are :—

(1) The dispersion of the target.
(2) It is easy to conform to the lie of the ground.
(3) Less dead foreground.

" The disadvantages are :—

(1) The difficulty of obtaining unity of command.
(2) Liability to assault owing to the impossibility of surrounding the whole position with a deep ditch.
(3) Difficulty in choosing the necessary enfilade fire positions.
(4) The communications cannot be fully protected ; for the cost of constructing the necessary lengths of bomb-proof passages would be prohibitive.*
(5) The cost is from 50 to 80% more than that of the ordinary modern fortress.*

" When considering the advisability of using this system we must remember the increased effect of artillery fire. Some of the disadvantages might, of course, be overcome by employing a picked garrison."

At Metz, the construction of these " points d'appui," or " Feste," as the Germans christened them, was inaugurated personally by the Kaiser in 1899. The best known is perhaps the Feste de Mercy (la Marne),† which was completed in 1911 at a cost of approx. £900,000, or nearly four times the price of Douaumont, and was sited as a defence against attack from the direction between Nancy and Pont à Mousson. This *feste*, which is about 5 miles from the centre of the town, consisted of three infantry works, arranged in a triangle, and two armoured batteries. The whole of the works cover a ground surface area of 14 acres and are all jointly interconnected by some 3,000 yards of concrete passages, often 150 feet underground. The centre work was the most important. Here, on the first storey, were the barrack rooms, bathrooms, etc., for the garrison, which consisted of 500 men exclusive of the artillery ; on the second, lower, storey were all the installations, *e.g.*, bakery, cook-houses, boilers for central heating, engine-room, oil storage, water tanks, etc. Everywhere was electric light, and electrically operated artificial ventilation, with a manual system superimposed in case of accident. The telephone exchange (one *feste* had 300 lines) was alongside the Commandant's Office, and he himself was provided with an electric lift to take him up to his armoured O.P. The works were surrounded by barbed wire, a steel palisade, and a concrete-faced ditch, relying for close defence upon machine-guns and pom-poms, some of which fired along the ditch itself. The batteries, each usually of 2 or 3 turrets, consisted of 105-mm. (4·2-in.) or 150-mm. (6-in.) guns under cupolas

* This did not deter the Germans.
† Described p. 154, Normand, in *Revue Militaire*, May, 1915, already quoted.

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8 in. thick, which were not of the disappearing type. The mountings were fixed and the muzzles projected several feet out of the cupola. Each battery had its own control O.P. The surrounding countryside is very similar to Salisbury Plain, yet these *festes* were remarkably inconspicuous, for everything was below ground level, and the batteries were only visible from the air.

In the years immediately before 1914 the Germans spent everywhere on fortifications more than twice as much as the French. The works at Metz were sited in depth and represented the last word in concealment, dispersion of the target presented to the enemy, mutual support, and concentrated local fire power, " wherein we may say that nothing hath been forgotten, either in wealth, diligence, invention or plenty of stuff."*

The main artillery defence was, as at Verdun, intended to be provided by mobile batteries.

Metz during the War.

Profiting by their experience on all fronts the Germans, in the course of the War, considerably strengthened the Metz defences. They installed 77-mm. guns in double cupolas to flank the intervals between the *festes*, and on the twelve-mile front between Arry (on the Moselle) and Sorbey, a line 8 miles south of Metz, they scattered over a depth of a mile more than 1,900 concrete pillboxes.

A few American shells falling in a suburb was the nearest Metz got to actual war. At the risk of appearing critical, it is curious that the vulnerability of protruding gun muzzles had not occurred to the Germans, and spare pieces were no cure. Furthermore, the lot of the garrison, hidden in the concreted bowels of the earth, would have been anything but enviable when the electric ventilating apparatus commenced to suck down air contaminated by gas shells. Whether the turrets would have stood up to shell fire as well as the Verdun ones did is problematic. The French have stated that the German concrete was not as well laid as theirs, and the armour plate over the cupolas was certainly four inches thinner.

III. Epilogue.

Liége fell because the field defences were sited in the intervals between the forts instead of well out in front of them—because the essential observation posts were to all intents and purposes indefensible and their loss made the forts blind and their armament useless—because it was deprived of the assistance of the field troops and the forts were accordingly isolated. Verdun was successfully defended as a result of the extreme gallantry of a very large field army, fighting

* La Noue, a Huguenot, in *Political and Military Discourses*, 1587, when referring to the citadel of Antwerp.

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in entrenchments elaborated during fourteen months of trench warfare; this system was, on the greater part of the front, thousands of yards in front of the perimeter of forts—the majority of the actual forts were only subjected to long range bombardment, which they withstood remarkably well, whilst their armament formed a very small percentage of the guns available—as concrete bomb-proofs these forts proved an invaluable asylum for the defending infantry, for which role they were not constructed—as *points d'appui* they showed themselves capable of prolonged defence, and the most sanguinary underground fighting occurred before they changed hands. Metz was never subjected to the acid test of war, but, if it had been, the very immunity which its garrison obtained by burrowing so deep might well, with gas shell, have proved its undoing.

Prophecy is dangerous, but it seems that there are certain deductions to be drawn which will enable us to frame some suggestions as to the design that the permanent fortifications of the future may take.

1. Fortifications will be sited in depth over an area in preference to the former linear perimeter. These areas will shield rather than surround the centre they are required to protect. The flanks will rest on natural obstacles or frontiers. Their full power will only be produced by the presence of first line field troops. They will act as bastions which will facilitate manœuvre by the main army, and by their potential strength they will form strategic obstacles to an enemy. They will probably not be in the immediate vicinity of the frontier. The area may be large, perhaps 50 to 100 miles, but then the cost of the works to be erected in peace will not be very great.
2. Isolated forts, *qua* forts of the old type, will not be built. In their place will be constructed :—

   (*a*) " Points d'appui " with great powers of local defence—a very modified type of *feste*.

   (*b*) Bomb-proof underground shelters.

   Both (*a*) and (*b*) will provide cover and strong points around which the mobile defence will be organized.

   (*c*) Armoured observation posts with an extensive system of telephone communications laid in pipes well underground. (W/T and R/T may avoid the necessity for the latter.)

   (*d*) A limited number of skilfully sited casemates for flanking fire, armed with machine-guns or quick-firing guns.

   With all of the above, depth will be the essence of the lay-out.

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The interior of Fort Lonçin in 1928.

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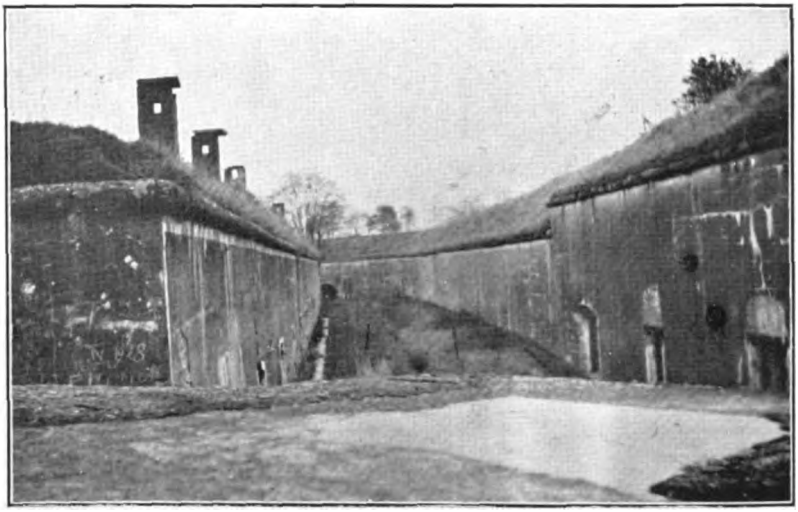
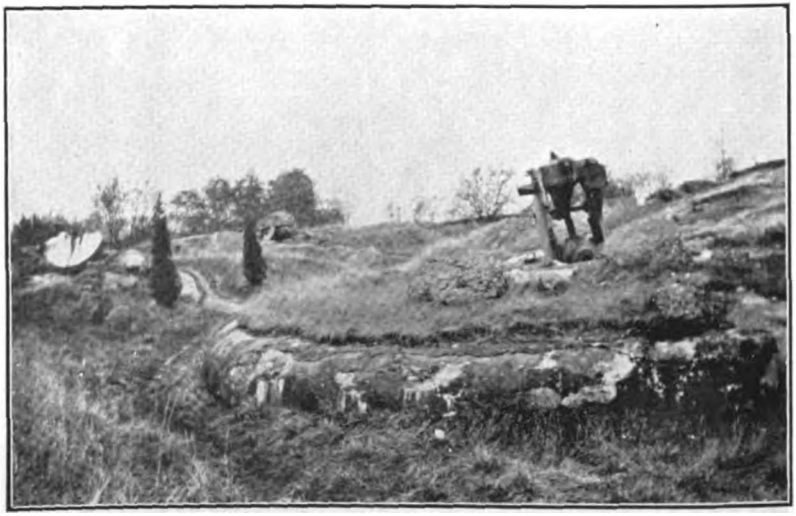


Fort Loncin.
Looking along the Gorge.



Fort Loncin
The southern part of the main rampart, showing a howitzer turret upside down.

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3. Now that the heaviest gun can be mounted on a travelling carriage, none of the artillery of the defence will be placed into permanent works (other than traditor guns mentioned at para. 2 (*d*)).

   The power of the counter-battery organization is such that any battery in an immovable concrete position is ultimately certain to be located, and even if it cannot be destroyed it will inevitably be neutralized. All the artillery will therefore be mobile ; in peace, it will be cantoned near or in the defended area ; in war, it will occupy previously selected positions where a careful plan of cultivation will provide natural concealment, and where a short line will connect the battery to the permanent telephone system and so to the existing armoured O.P.s. This policy would be an economy and an immense improvement on the old practice, for should the course of the war justify it, all the defended area artillery could be withdrawn for use with the field army.

4. All permanent buildings in the area must have gas-proof chambers, and some installation whereby the supply of pure air can be guaranteed.

5. Tactical tank obstacles, on the principle of tactical wire, must be prepared so that they are immediately available, for an " attaque brusquée " by an armoured mobile force is most to be feared.

The influence which fortifications can exercise in the realm of grand strategy is rarely alluded to. In the case of the German plan for the invasion of France, Von Schlieffen certainly considered them. He knew the line of the Meuse and Moselle from Verdun to Epinal bristled with forts. He was aware that the French had neglected to keep up-to-date the fortifications facing the frontier north of Verdun. He correctly appreciated the powers of resistance of Liége. He rightly assessed that Alsace-Lorraine would attract a French offensive like a magnet. He foresaw that if he attempted an ambitious enveloping movement then his right wing could never be too strong. He therefore strongly fortified his southern flank, only leaving a gap of difficult wood and lake country, and when these works were approaching completion the " Schlieffen " plan was adopted. In 1912, von Moltke stated that the violation of Belgian neutrality " presents more chances than a frontal attack against the fortified screen in eastern France, which would result in the operations degenerating into a war of fortresses, occupying many months, and tending to deprive the army of the *élan* and initiative which are its greatest assets."* General von Kuhl in *Der*

* Ludendorff, *Documents du G.Q.G. Allemand*, quoted by Normand, p. 150.

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Marnefeldzug wrote that " only the existence of the line Verdun–Toul–Epinal–Belfort compelled us to undertake the invasion *via* Belgium."*

The French plan has been severely criticized by many writers. Their III Army observed Metz, whilst they launched their I and II Armies, to be weakened as the offensive progressed, into the difficult terrain in the gap between the Metz defences and the Vosges. The effect which the " declassified " fortifications on their northern frontier might have seems to have been overlooked, and it was anticipated that the Germans would make the same mistakes as themselves and attempt to manœuvre large forces through the openings in their fortified line, *i.e.*, *via* Stenay, north of Verdun and *via* Charmes, between Toul and Epinal—the one 18, the other 30 miles wide. In *Les Bases du plan XVII*, the French General Staff forecasted to within two Divisions the numbers which Germany would deploy against them, but they miscalculated by twelve Divisions the strength of the force which could be rapidly detrained and concentrated north of Trèves, and hence failed to appreciate the true danger of the outflanking movement through Belgium which they suspected might develop. Furthermore, " it was estimated that an important rôle would be played by the group of armies which would concentrate behind the Metz–Thionville position, and it was always believed that, for reasons of policy and morale, the Lorraine plateau would prove an attraction to the Germans."† In 1876, when he planned the northern defences of France, General Séré de Rivières laid it down that " the role of these places is no longer to ensure the possession of great cities or centres of communications, but to cover mobilization, to protect concentration, either to allow operations against the flank of an invader to be staged in complete security, or to serve as pivots of manœuvre, *or finally to ensure protection against turning movements which have become such a danger in an age when the improvement in firearms has deprived a frontal attack of any chance of success.*"‡ The italics are mine. The shade of this able soldier must have been a very perturbed spectator at the Council on 18th April, 1913, when Plan XVII was adopted.

* Quoted by Normand, p. 151. Von Kuhl was Chief of Staff to Von Kluck.
† See p. 40, *Les Armées Françaises dans la Grande Guerre*, Book I, Vol. 1.
‡ p. 146, Normand, *Revue Militaire*.

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L.O.X.

(*The Modern High Explosive.*)

By COL. R. E. M. RUSSELL, C.B.E., D.S.O., *Military Attaché, Chile.*

1. A visit recently paid to the great Chuquicamata copper mine, in Northern Chile, gave the writer an insight into the use as a high explosive of carbon soaked in liquid oxygen (familiarly known in this context as " L.O.X."), which may be of some interest to his brother officers and to the Service generally.

Nothing is to be learned on the subject from Service, or other easily accessible, textbooks, and the writer has only once previously come across an instance of its practical use, namely, in 1926 and 1927, for the blasting of rock in the construction of the canals and power house of the Shannon hydro-electric plant between Limerick and Killaloe.

There may even be others who share the writer's previous ignorance of the fact that the saturation with liquid oxygen of a mixture of finely-divided carbon and soot, without any further ingredients or process of any kind, produces immediately an explosive whose rate of detonation is 40 per cent. higher, and whose locally destructive effect is 20 per cent. greater than those of commercial 65 per cent. ammonia dynamite, and which is reasonably safe to handle in bulk, though easily detonated by cordeau without the use of any primer or other detonator. And, further, that this explosive, after the lapse of a few hours, becomes, by the evaporation of the oxygen, again completely inert. The sole product of the chemical action which causes the mixture to detonate is the inert but non-poisonous carbon dioxide gas.

The only raw materials required for its manufacture are charcoal, soot and air ; and the only plant necessary consists of air filters and compressors (driven by any available source of power), expansion vessels, pumps, and vacuum insulated containers.

2. The scale on which the Chuquicamata mine works will be apparent from the description that follows and will enable an appreciation to be formed of the value of the experience which is there gained.

The bulk of the ore is of low grade, averaging 1·6 per cent. of metallic copper, but the deposit constitutes the largest single copper ore body in the world. It occurs close to the surface, necessitating the removal of an overlaying sterile stratum of only a few metres in

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thickness, in order to expose an ore bed, covering an area of 2½ kilometres by 1¾ kilometres to a great depth, there being sufficient ore in sight to enable mining to be carried on by surface methods at the present rate for some eighty years.

The issued capital is approximately £30,000,000, held almost entirely in the United States, and the mine is potentially the greatest producer of copper in the world, being fully equipped for dealing with 50,000 tons of ore per diem, though it is at present being held back by market considerations to the third place amongst producers with an input of 32,000 tons of ore per diem. This enormous quantity is put through the mill day in and day out, with mathematical precision, the variations between one day's supply and another being extraordinarily small.

The whole of it, and also the corresponding waste covering, is quarried by the use of explosives of various natures, according to the nature and situation of the rock or soil to be moved. Some six million pounds weight (2,700 tons) of explosives are consumed each year, making this mine probably the largest user of explosives in the world.

Individual blasts at Chuquicamata are large, black powder shots which dislodge masses of rock averaging 250,000 tons each, and high explosive shots which dislodge masses averaging 80,000 tons each.

The largest single shot yet fired involved the use of 788,000 lb. of dynamite and 76,000 lb. of black powder—altogether 385 tons of explosive (L.O.X. had not then been introduced)—in 8-in. bore holes, averaging 52 feet deep. Twenty miles of cordeau fuse were required to ignite it.

Before the introduction of L.O.X., an ammonia dynamite of about 65 per cent. strength was being exclusively used in the hard underlying ore body, where a strong disruptive as well as a displacement effect is required for breaking the rock. Part of this dynamite was manufactured in a neighbouring factory, and the remainder, under the trade name of "Sikrit," imported from Norway.

It was desired to attempt to effect economies by replacing this relatively high-priced explosive in the smaller blasts, but it has not been considered economical to replace the black powder which is manufactured by the mining company itself on the spot, at very low cost.

L.O.X. was accordingly introduced on a considerable scale in 1927, and as a result of a year's experience, it has been decided to triplicate the present plant, which is capable of producing 126,000 lb. of liquid oxygen per month.

The cost comparison is very favourable to L.O.X., which works out (including full provision for overhead charges, manufacturing losses, etc.) at 8½ cents (U.S.A.), or about 4¼ pence per pound, as compared with 16 cents or about 8¼ pence per pound of dynamite,

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while the " duty " factor, for blasting in bore holes on existing faces, has been found to be 3·78 tons of rock broken per pound of L.O.X., against 2·9 tons for dynamite.

3. The proposition appears an extremely attractive one for military purposes, but there is at present one grave disadvantage, namely, that the technique up till now employed necessitates the preparation of the explosive immediately before use, while the transport of the saturated carbon, or of the liquid oxygen alone, for any considerable distance or time, involves a high rate of wastage by evaporation even when carried in bulky and delicate vacuum insulated containers. The extent of this loss may be appreciated from the fact that it has been established that in a bore hole charge fired 1½ hours after commencing to soak the cartridges, only 58 per cent. of the oxygen used originally in soaking them is usefully employed, and within three hours after laying the charge is completely inert. The industrial purposes to which the explosive is at present confined are not insurmountably inconvenienced by this characteristic, but further research and experiment are necessary before L.O.X. can be made available for anything approaching general military use.

Trouble has been experienced in attempting to use L.O.X. in small diameter holes in underground workings. A large mine in Peru, working under these conditions, and using 2-in. and 1¼-in. drill holes, has abandoned its use after several accidents thought to be caused by the abnormally high rate of oxygen evaporation from the relatively large surface of the small bore cartridges.

4. Before entering into details and technicalities, a short general description of the method here used of preparing and using L.O.X. may enable the process to be more readily understood.

(*a*) 8-in. bore holes in the mine face are drilled and cordeau laid from the bottom to about 9 in. above the top (but not connected to the firing mains).

(*b*) Liquid oxygen is manufactured by compressing, cooling and expanding clean atmospheric air, and is stored in 1,000-gallon vacuum insulated containers in a building alongside the railway track.

(*c*) Cylindrical " cartridges," consisting of a mixture of two grades of finely-divided carbon, one as fine as soot and the other slightly coarser, loosely contained in canvas bags, 7 in. in diameter by 20 in. long (weight, 8 lb.), or 5¼ in. by 12 in. (weight, 3½ lb.), are packed in heavily-insulated wood soaking boxes, carried on shaded railway cars alongside the oxygen house.

(*d*) The liquid oxygen is run through flexible hoses into the soaking boxes in sufficient quantity to enable each cartridge to absorb a pre-determined weight of the liquid, and the cars are run out to the site of the blast.

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(*e*) The " wet " cartridges, now weighing about 31 lb. (or 14 lb. each), and " steaming " freely, are off-loaded on to hand-barrows and placed alongside the bore holes, where they are dropped by gravity to the bottom (average depth 45 feet), and tamping sand shovelled in. The cordeau leads are then jointed up to the cordeau firing mains. Total time from oxygen factory to time of firing about 70 minutes for a train of about 1,000 31-lb. cartridges, which necessitates extremely smart work, everyone moving at the run.

5. BLASTING PRACTICE.

(a) *Drilling.* All charges are fired in 8-in. bore holes, whose depth is regulated by that of the working face, and averages about 45 feet. These holes are drilled by " jumper " (locally called " churn ") drills, operated electrically. The pattern which has been standardized is the Saunderson " Cyclone " portable mine rig, type 14 S.R., driven by a motor using 23 amperes at 500 volts, manufactured at Oreville, Ohio, U.S.A.

Eighty-seven of these rigs are in constant use, 24 hours per day in 3 shifts, and drill about 36,000 feet per month, at an average cost of 5s. 1d. per foot run, including full provision for overhead and maintenance expenses. Many of the holes have to be lined for 10 or 15 feet with light steel tubing, owing to the disintegration of the ground caused by previous explosions.

(b) *Charging.* Each hole is individually sited by a mine engineer, and its position recorded on a map. As drilling progresses, an accurate record of the material passed through is kept by the foreman, and with these data shot plans are made up in the mine engineering office, and a " prescription " issued for each hole. Certain holes are chambered or " sprung " at the bottom by the explosion of small charges, in order to enable main charges of as much as 2½ tons to be concentrated. Some holes are given multiple charges, varying weights of different explosives being laid at different levels in the hole and separated by sand tamping.

The use of a free running explosive is desirable for charging the chambers, and some difficulty was expected when L.O.X. was substituted for Sikrit, which is a dry granular substance, pouring and packing freely, owing to considerable loss in the density of the charge. It was found, however, that the increased speed of detonation (5,200 metres per second) more than compensated for the loss of density.

All holes are inspected with a mirror before charging, and no attempt is made to force the bulky L.O.X. cartridges down ragged or crooked holes. The only accident which has yet taken place with L.O.X. was the result of an endeavour to do so. (No one was seriously injured.) The cartridges drop freely by gravity without danger. (See Photos Nos. 1 and 2.)

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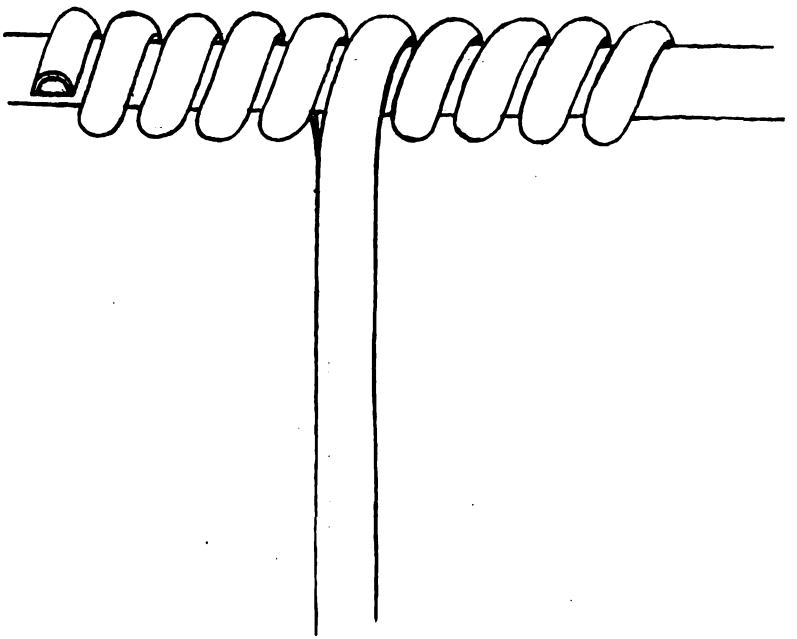
Accidents of any kind are rare, and confined almost entirely to failure to detect " blind " dynamite charges until the power shovel has got to work.

Remarkably little surface effect is produced even by the explosion of shots of 170 tons of high explosive, such as the writer witnessed, owing to the scientific application of the material, the ideal being to leave the rock as far as possible in situ, broken up sufficiently small to be dealt with by the shovels, but otherwise undisturbed. (See Photo No. 3.)



Joint of Cordeau branch to main.

Many of the lining tubes can be partially used again, the most damaged parts being cut off.

(c) *Ignition.* Ignition is done entirely by cordeau fuse, without the use of any sort of primer or other detonator.

Two patterns of cordeau are used, that which is inserted in the bore holes having the lead tube protected by wire braiding, while the connecting mains are of the ordinary bare lead service type. The jointing is interesting, as being much more simple and economical than Service practice, and so successful that I was informed that no failure of a joint had ever been experienced.

Two lengths are joined end to end by simply butting the ends, freshly square cut, together in a thin copper sleeve which is pinched over them by a special pliers.

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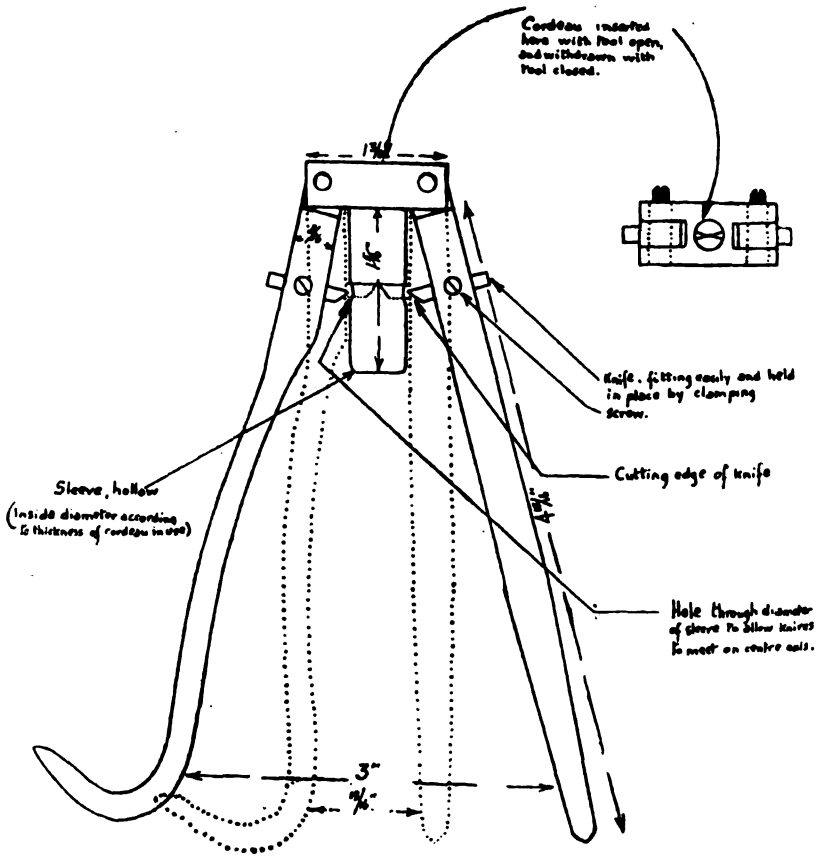
A branch is jointed to a main by splitting the end with a special tool (see Sketch " A "), for about four inches, and tightly wrapping the split portions in opposite directions round the outer surface of the main. The tool resembles a pair of nut-crackers, with a sharp cutting edge of sufficient length to reach the centre of the cordeau inserted in the centre of each jaw, and a sleeve of sufficient diameter to admit


Cordeau inserted here with tool open, and withdrawn with tool closed.
1¾"
⅜"
1⅛"
Knife, fitting easily and held in place by clamping screw.
Cutting edge of knife
Sleeve, hollow
(Inside diameter according to thickness of cordeau in use)
Hole through diameter of sleeve to allow knives to meet on centre axis.
3"
⅞"

Sketch "A."—Special Tool for Splitting Cordeau.

Full lines show tool open ready to insert cordeau.
Dotted lines show tool closed.

the cordeau through the axis between the handles. The cordeau is inserted through the sleeve, the cutting edges pressed home through the lead tube, and the cordeau then drawn out by hand, keeping the instrument closed. The cordeau is thus neatly sectioned, leaving two clean strips of explosive exposed.

As rain is almost unknown in Chuquicamata and all charges are fired within a few minutes of connecting up, the question of protecting joints against weather does not arise.

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In the lay-out of a large shot, cordeau mains are run out along the lines of holes by unreeling from large drums. These mains are cross connected every hundred yards or so and the ends of the braided cordeau which protrudes from the charge holes are rapidly split and wrapped to the mains, but not before everything is reported as otherwise ready.

The main system is then detonated in one point by a commercial pattern electric detonator, the joint being made in a special copper ferrule, into one end of which the cordeau is nipped by a special pliers, and in the other end of which the detonator, with its point in contact with the cordeau, is held by the natural spring of the copper ferrule, which is split. (See Sketch " B " page 50.)

Detonators are tested for resistance and continuity in test boxes immediately before use, and not more than one is ever used for firing even the largest groups, sometimes consisting of several hundred holes.

By means of these blasts, the hillsides are worked into tiers of " benches " or gigantic steps, the average vertical rise of each step being about 45 feet, and the horizontal width equal to 2½ times the height, plus 15 metres, so as to give room for a double line of railway, a line of power shovels and the drilling rig preparing the next face for blasting.

The rock is disintegrated to a depth of about five feet below the working level of the bench, so as to facilitate track laying and shifting, which is done mechanically by a heavy electric locomotive provided with a steel beam projecting horizontally athwart the track at sleeper level. This beam smooths the shattered rock sufficiently to form a bed for the track, which is then unfished and slewed in lengths of sixty feet or more, into its new alignment by an electrically operated tackle, working from the end of the beam. Scarcely any manual labour is required, and the finished track is good enough to take with safety the 100-ton (gross) ore trucks used.

Over twelve miles of bench are at present being worked.

6. Manufacture and Storage of the Liquid Oxygen.

Air inspired through a dust-excluding inlet is first compressed to 853 lb. per square inch in a three-stage Ingersoll-Rand compressor, driven by a 175 h.p. electric motor.

This compressed air is then circulated through oil extractors, cylinders containing caustic soda (to remove CO_2) and quick-lime (to remove moisture), to a heat exchanger in which it is partially cooled.

A portion of the compressed air is then used to drive an expansion engine, causing further cooling of the portion of the air which expands and the compression of the remainder to 2,845 lb. per square inch.

At this pressure, the oxygen content of the air liquefies at a temperature of −182°C., while the nitrogen remains gaseous until −194°C. is reached.

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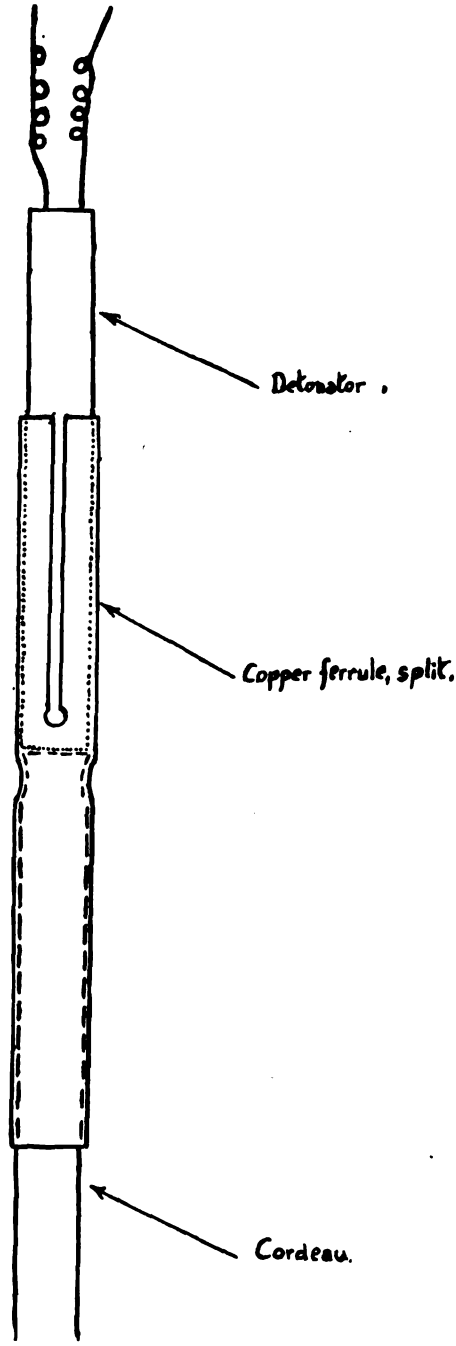

Sketch "B."

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The temperature of −182°C. is attained in a liquefaction apparatus (Claude system by L'Aire Liquide, Paris), without mechanical aid by a simple process of partial expansion and heat exchange, and the effluent is practically pure liquid oxygen which gravitates directly to the storage containers through ⅝-in. copper pipes, insulated by passing through 3-in. steel pipes, which are lined with a thick layer of hair felt, and contain a counter flow of cold oxygen gas from the liquefaction apparatus.

The liquid oxygen, when drawn off in a mug, resembles water, but has a slight steely colour and is in constant ebullition, with the appearance of "steam," caused by the freezing of moisture in the surrounding air as the intensely cold gas comes in contact with it. Mercury poured into the mug freezes instantaneously, and a rubber tube becomes as brittle as thin glass.

The whole of the above apparatus, with the exception of the expansion engine, is perfectly simple, everyday plant, and occupies but little space, owing to the purifying of the air being done after the reduction in its volume by the first stage of compression. A hut of about 40 feet by 20 feet houses the whole, with plenty of room for additions.

The expansion engine, with the second-stage compressor, is more delicate and requires careful adjusting of valves and packings.

The plant seen in operation was designed to produce 75 litres (about 16½ gallons, or 150 lb.) of liquid oxygen per hour, and in practice gives 73 litres at an all-in cost of seven cents, U.S.A. (or about 3½d.) per litre, or 1½d. per lb. It is worked 168 hours per week, whenever possible, to avoid starting losses, but even then, some 28 per cent. of the liquid is lost during the week's operation.

The liquid oxygen is stored in three vacuum jacketed containers, having a total capacity of 10,000 litres (*i.e.*, about 750 gallons each).

The jacket is maintained by Goede Mercury diffusion pumps and Cenco-Hyvac oil pumps at a vacuum of between 0·0001 and 0·00007 millimetres of mercury. Both inside and outside walls are of ⅛-in. steel boiler plate, covered internally with smooth sheet copper, which immediately before assembly is polished to mirror brightness in order to insulate against heat radiation. They are, in fact, "thermos" flasks on a large scale.

The heavy plating is necessary to withstand the pressure due to the vacuum on large surfaces which cannot be stayed on account of the loss of insulation which any support would cause. The reduced strength of the steel at the low temperature has also to be taken into account.

The containers seen were designed by the Purox Co. of Denver, U.S.A., and manufactured by the American Welding Company.

No material difference is being made in the new plant now on order, which will have three times the capacity of the original plant.

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7. MANUFACTURE OF CARTRIDGES.

Cylindrical bags of the required size, namely, 7 in. in diameter by 20 in. long, for 8-lb. loads, and 5¼ in. diameter by 12 in. long, for 3½-lb. loads, are machine-made from No. 8 cotton duck.

The carbon mixture in use consists of 65 per cent. "Bugbird," a proprietary coarse-grained carbon produced by burning woodpulp, and 35 per cent. "Huber" gas black (a very fine soot). The power of absorption of oxygen, rate of detonation, sensitiveness, and mechanical strength of the cartridge are all materially affected by the natures and proportions of the carbons used.

They are intimately mixed in an overhead hopper by plant similar to a wheat-flour mixer, and the mixture descends through a pipe over the lower end of which the empty cartridge bag is placed. When full, the end of the bag is closed by a brass clip. About 350 bags per eight-hour shift can be filled by one man. It is a dirty job.

8. SOAKING OF CARTRIDGES.

Cartridges prepared as above will absorb up to 3·4 times their weight of liquid oxygen, and gain progressively in explosive strength with the amount they absorb. To attain this maximum, however, it is necessary to keep them wholly immersed for forty minutes, with consequent large expenditure of oxygen and waste by evaporation, and unusable dirty residue. The most economical result has been found in practice to be attained when the cartridges are only partially covered, and allowed to soak for twenty minutes. Under these conditions they absorb 2·9 times their dry weight of oxygen.

The dry cartridges are packed in layers into stout waterproof-covered wooden boxes, 72 in. by 36 in. by 22 in. (holding 50 large or 125 small cartridges), insulated on all six faces by 4 in. of "balsa" wood, and carried permanently on shaded railway trucks. (See Photo No. 4.)

Immediately before being required for use, about 800 litres of liquid oxygen are run into each box from the vacuum-jacketed storage containers, through canvas-covered flexible metal hoses. The twenty minutes average time taken to run the trucks to the vicinity of the bore holes is sufficient to enable the requisite amount of liquid to be absorbed and the cartridges are unloaded and laid as above described immediately on arrival.

Waste liquid remaining in the boxes is recovered in portable "thermos" bottles and used (after filtration) in connection with the cooling portion of the plant.

From the moment when soaking commences, the cartridges have to be treated with the precautions customary in the case of all high explosives, i.e., rough handling has to be avoided and great care taken to avoid contact with sparks.

Soft-soled shoes should be worn and steel fittings dispensed with.

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9. STATISTICS.

It is estimated that, at the moment of firing an average charge, normally within 1½ hours after having commenced to soak the cartridges, the oxygen-carbon ratio which was originally 2·9 has been lowered to 1·88.

Only 30 per cent. of the liquid oxygen originally manufactured is usefully employed, the remainder being accounted for as under:

Pipe losses between plant and reservoir	5%
Storage losses (one week)	23%
Soakage losses	16%
Evaporation after soakage	17%
Recovered from soaking boxes in thermos bottles	2%
Not recovered from soaking boxes	7%
Total	70%

It is necessary to manufacture 5·9 lb. of liquid oxygen for every lb. of dry cartridge.

The rapid loss of weight by evaporation makes statistics difficult to compute, and introduces an indeterminate factor for which a mean value based on experiment has to be assumed.

The following tables of costs* are obtained from figures kept during one month of 1927, in which were manufactured:

6,579 cartridges weighing (dry) 23,027 lb., and
126,000 lb. of liquid oxygen.

TABLE "A."—CARTRIDGES.

	Total Cost.	*Cost per lb. of cartridge.*
14,968 lbs. Bugbird carbon black	$1600·08	$0·069
8,059 lbs. Huber gas black	$1195·15	$0·051
2,192 yds. 36 in. No. 8 canvas duck	$544·08	$0·024
Brass clips and thread	$85·54	$0·004
Labour	$83·98	$0·004
Supervision and overhead charges	$69·08	$0·003
Power and maintenance	$20·85	$0·001
	$3598·76	$0·156

TABLE "B."—LIQUID OXYGEN.

	Total cost.	*Cost per lb. of liquid.*
105,526 kw. horse-power at $0·00868 ...	$915·97	$0·007
Labour, 10 men	$543·60	$0·004
Supervision	$370·00	$0·003
Maintenance	$240·00	$0·002
Chemicals	$94·14	$0·001
Water, lubricants and miscellaneous	$47·13	$0·001
Interest and amort. on capital at 10½% per annum	$1290·00	$0·010
	$3500·84	$0·028 or $0·0716 per litre.

* Dollars (U.S.A.) at $4·86=£1. ($1=4s. 1½d.)

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TABLE "C."—L.O.X.

Cost of 1 lb. of dry cartridge (Table "A")	$0·156
Cost of 1·88 lb. of liquid oxygen actually exploded (equivalent to 5·9 lb. of liquid manufactured), at $0·028 per lb. (Table "B")	$0·165
Cost of 2·88 or, say, 3 lb. of cartridge (sum of above) ...	$0·321
Cost of cartridge weighing 1 lb. at time of explosion ...	$0·107

TABLE "D."—SUMMARY OF STATISTICS DURING FIVE MONTHS OF 1927.

Rock broken			937,195 tons
L.O.X. used	Liquid oxygen manufactured	494295 lb.	
	Liquid oxygen wasted ...	330565 lb.	
	Liquid oxygen actually exploded ...	163730 lb.	
	Dry cartridges exploded ...	83830 lb.	
	L.O.X. actually exploded		247, 560 lb.
Weight of rock broken per lb. L.O.X.			3·78 tons.
Dynamite required to break above amount of rock			312000 lb.
Cost of 247,560 lb. of L.O.X., at 0·107 (Table "C")			$26488·92
Cost of 312,000 lb. dynamite, at 0·16			$49920·00
Saving effected by use of L.O.X.			$23431·08 or 47%

Cost of L.O.X. replacing 1 lb. of dynamite at 0·16 (8d.)

$$= \frac{247560}{312000} \times 0·107 = \$0·085 \ (4\tfrac{1}{2}\text{d.}).$$

10. GENERAL.

(*a*) A few general particulars of this mine and of the process used may be of interest.

Owned by the Chile Exploration Company, it is situated in latitude 22° S., longitude 9′ W., about 10 miles north of the Calama Station of the Antofagasta-Bolivia Railway, in hilly country, entirely without previous population, water, fuel, fauna or flora, and about 9,500 feet above sea level. Not the least remarkable feature of the organization is the way in which these inherent difficulties have been overcome.

The principal "township" has a normal population of 15,000 souls, and is laid out as "garden city" of excellent reinforced concrete houses of pleasing appearance, provided with water supply and water-borne drainage, and many with small gardens or enclosures. The workmen, all Chileans who have never before seen such luxury, bring their families, for whose education, health, amusement and general welfare the most complete arrangements are made. For instance, the main hospital has a staff of five doctors and forty trained nurses, with such equipment and apparatus as is rarely seen; a special maternity hospital is provided on the same scale; there are several schools, clubs, two theatres, fine recreation grounds, swimming baths, and many retail shops in which all commodities are sold at 10 per cent. *under* cost price. And last, but not least, a retired serjeant of the Royal Artillery has charge of the sports and gymnasia.

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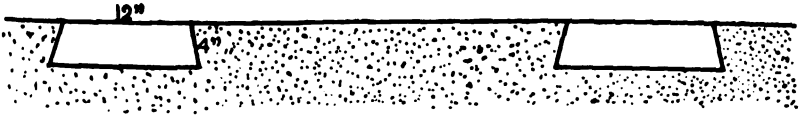
The expense, of course, has been enormous, but it is interesting to note that those concerned consider that full value has already been derived therefrom. The best class of workman is obtainable without difficulty and there has never been a trade dispute, even in times of most acute industrial tension. It is typical of these large New World organizations that they consider it bad policy to pay a man and give him expensive plant and machinery to handle unless he is kept in the best mental and physical state to obtain the maximum advantage from it.

Labour is paid, as far as possible, by piece work or by small contracts, in which the Company provides plant and appliances. Every man can earn, and most do earn, very considerably more than the standard time rates of the country. It is rare to see a man working with his unaided hands.

Water is piped from two sources in the Andes, distant 80 and 65 miles, and is supplied in unlimited amount.

All power is electric, 158,710 kilowatts being generated on the Pacific Coast, 85 miles distant, by oil-fired steam and Diesel engines, and transmitted by overhead line at 110,000 volts, at an all-in cost of $0·00868 (about 0·4d.) per unit at the mine.

Inexpensive and entirely practical motor routes are made through the soft desert by building concrete wheel tracks. Some were seen which have withstood years of traffic by heavy vehicles, and the cost is infinitesimal in comparison with that of a road which would give equal service.



Section of Concrete Wheel Tracks.

The ore comprises a complexity of copper compounds, of which sulphates, sub-sulphates and chlorides are at present chiefly worked. Proportions are adjusted so as to give a milling assay of about 1·6 per cent. of metallic copper, though as low as 1·4 per cent. has been profitably dealt with. A plant for dealing with copper sulphides will be erected when required.

The process consists of the following steps:

1. Quarrying.
2. Crushing.
3. "Leaching," *i.e.*, extraction of the copper from the ore by soaking in acid solutions.
4. De-chloriding.
5. Electrolysis.
6. Smelting.

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(*b*) *Quarrying*. The quarrying process has already been described. The resultant shattered rock is loaded into ore trucks (average tare 68 tons) by electrically-driven " Bucyrus " power shovels, of from ¾ cubic yard to 8 cubic yard capacity, the standard being the 4 cubic yard shovel, some of which run on rail track, some on caterpillar tracks. The 8 cubic yard caterpillar shovel weighs 230 tons, and the 4 cubic yard shovel 160 tons.

Haulage to the mill is by electric locomotive, those on the working face being accumulator or petrol-electric drive, those on the permanent line taking the current at 500 volts from a third rail.

Cost of loading and hauling from mine face to mill $0·177 (about 0·08d.) per ton of ore, as against $0·682 (about 0·32d.) per ton by the steam shovels and locomotives which were formerly used.

(*c*) *Crushing*. The ore trucks (each about 100 tons gross) are pushed by an electric " mule," two at a time, into a cylindrical tip, which empties them into an ore hopper by rotating them through an angle of about 160°.

When empty they are pushed out of the tip by the next incoming pair of trucks, and run by gravity to a sorting siding. Time, 40 seconds for discharging each pair of trucks containing about 136 tons of ore.

The ore is then reduced from rocks of several tons weight to a gravel of ⅝-in. mesh by a succession of crushers of different types, in the largest of which the oscillating core weighs 86 tons, the dust, which contains 4 per cent. of copper, being carefully collected by aspirator fans.

(*d*) *Leaching*. The " gravel " is conveyed by 52-in. belt conveyors, about a kilometre long (cost, £3 per foot run), to belt distributors feeding over large mobile cantilever bridges a series of concrete tanks, each about 300 ft. x 150 ft. x 20 ft. Dilute acid liquor, containing 5 per cent. sulphuric acid, is run in from the bottom and converts 96 per cent. of the copper into copper sulphate in solution. A second washing is given with more dilute acid and a third with water.

(*e*) *De-chloriding*. The object of this process is to remove all traces of chlorides (mostly those of sodium, potassium and magnesium) before electrolysis, where they would, if present, be decomposed into chlorine gas and render work impossible.

The liquor from the leaching tanks is mixed in concrete vats with very finely divided copper (known as " cement " or " amorphous " copper), suspended in water. This combines with the chlorides, forming cuprous chloride, which is then brought in contact with scrap iron (of which about 40 tons per diem are expended), in rotating bronze drums, and combines with it to form ferrous chloride (which is wasted), and a larger amount of amorphous copper than was originally used. Sufficient is retained to continue the process and the remainder is smelted in a special small furnace.

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Photo No. 1.—Dropping 30 lb. L.O.X. cartridge down bore hole.

Photo No. 2.—Charging bore holes with L.O.X.

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Photo No. 3.—Explosion of 170 tons of L.O.X. and Dynamite.

Photo No. 4.—Unloading of L.O X cartridges from the soaking boxes at the site of the blast.

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(*f*) *Electrolytic Process.*

(*i*) The *electrolyte* contains nitric, sulphuric and hydrochloric acids in addition to the copper sulphate in solution.

(*ii*) The *anode*, made of a copper-iron silicate, evolved and manufactured at Chuquicamata, is cast in the form of a grid, about 6 ft. x 4 ft., with copper rod reinforcement, from the material formed by fusing with scrap copper in an electric furnace the silicon-iron alloy imported from Norway. The resulting compound contains about 60 per cent. copper and 20 per cent. silicon, with iron and impurities. Is electrically a good conductor and almost indestructible.

(*iii*) The *cathode* is made by depositing copper electrically for about 24 hours on an oiled copper matrix, about 6 ft. x 4 ft., when thin copper "starting sheets," weighing 13 lb., and easily separable from the matrix, are formed. These are removed and used as separate cathodes for 7 to 10 days, during which they are built up to a thickness of $\frac{3}{8}$ in., and a weight of 160 lb. of copper, about 99 per cent. pure. The impurities comprise traces of gold and silver, a little iron, some sulphur and other chemical and mechanical substances, which have to be further reduced by smelting.

(*iv*) The electric current is used at the rate of 17 amperes per square foot, at very widely-varying voltages, the maximum being about 60. 60,000 k.w.h. are used in the shop and the field near the vats is so intense that the individual keys of a bunch held in the hand, while walking in the alleyways, are visibly affected, and it is, of course, at once destructive to a watch.

(*v*) The liquor after the copper is all deposited consists largely of dilute sulphuric acid, with nitric and hydrochloric acids as impurities. Some of it is required for the leaching process but there is a large excess and some 3,000 tons of sulphuric acid are run to waste every month, as the distance of any possible market precludes the expense of purifying it.

(*g*) *Smelting.* The electrically deposited sheets are smelted to reduce them to a more marketable form and get rid of the impurities, raising the percentage of pure copper to 99·95, most of the remainder being gold, which would not repay the cost of extraction.

The melting is done in reverberatory oil-fired furnaces, which require seven hours to melt the charge. Most of the impurities pass off as gas, and the remainder form a slag. The copper oxide produced on the surface is reduced by the insertion of charcoal and by periodical stirring (mechanically effected) with poplar poles.

The molten copper is run off through pneumatically-controlled doors, into moulds carried on continuously rotating tables, whence

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they automatically upset, depositing the ingots on a conveyor where they are quenched by water jets and carefully inspected, cinders and surface blowholes being cut out with pneumatic chisels.

" Wire bars " and wedge-shaped ingots, weighing 220 lb., are the most usual form.

(*h*) *Tailing Disposal.* The tailings, in the form of clean gravel, of about $\frac{3}{8}$-in. mesh, are transferred from the leaching tanks to railway cars, by rapidly operated grabs worked from two immense movable bridges, in which are incorporated hoppers with pneumatically-controlled chutes.

A train of 32 tip-cars (each 20 tons tare and 20 tons load) is filled from the hoppers in 12$\frac{1}{2}$ minutes, motion being almost continuous, and pushed to the tip (186 feet high at present) by an electric locomotive. Tipping takes 2$\frac{1}{2}$ minutes, the train being in motion all the time and only 4 men being required, one to drive the train, 3 to knock the pins out of the tip-trucks (which right themselves automatically when empty). The locomotive takes current from a third rail until near the site of the tipping, where it changes to an overhead wire.

The gigantic scale of the whole plant cannot be appreciated without seeing it, but some idea can be obtained when it is recollected that it is designed to deal with 50,000 tons of ore per diem, and that the leaching and electrolysis are slow processes taking many days.

At every stage, there are to be seen examples of organization and every branch of engineering on the largest scale. Graphs showing all material figures are kept and circulated daily to every department, and the whole concern works like a well-run army headquarters in war, with a well-organized chain of command, everyone with plenty to do and no one unduly busy, the " G.O.C." having more spare time than anyone.

It is to the more-than-efficient " G.O.C." or (as he has it) to the " General Manager," Mr. Burr-Wheeler, that I am particularly indebted for devoting a whole day of his valuable time to showing me round in person, and to him and his assistant, Mr. Woodhul, and to Mr. Bellinger, a vice-president of the Company, not only for most kindly hospitality, but also for providing me with the general information which I have endeavoured to record above.

For the particular information on the subject of L.O.X., I am very grateful to Mr. Dunbar, who was in charge of that department at the time of my visit, and to Messrs. Schultz and Hunter, who recently contributed a valuable paper on the subject to the American Institute of Mining and Metallurgical Engineers, and have allowed me to use some of their data.

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AN ATLANTIC LINER FROM INSIDE.

By LIEUTS. F. M. HILL and H. E. M. COTTON, R.E.

THE following Notice was circulated to students at Cambridge :—

"THE directors of the Cunard Steam Ship Co., and the directors of the White Star Line, are again kindly offering facilities to a certain number of Cambridge engineering students to gain engine-room experience, on round voyages to America or Canada, between June and September next, each voyage extending over a period of approximately three weeks.

These voyages are intended for second-year students only, and the first choice will be given to those who are reading for honours.

Individuals selected will become temporary members of the engineers' mess. They will be under the authority of the Chief Engineer, and will have definite duties to perform. To avoid passport difficulties, they will be signed on as members of the engineering staff, and receive pay at the rate of one shilling per month. On the other hand, they will be given free board and lodging during the voyage, and can live on the ship while it is in port.

I shall be glad if gentlemen who wish to avail themselves of this opportunity of combining engineering experience with a voyage to America or Canada, will apply to the office at Scroope House for an application form, fill this up and send it in to Mr. A. H. Chapman, Room 11, Scroope House, as soon as possible. No applications can be considered after May 4th.

Dates of sailings will be posted later."

FOR several summers, the Cunard Co. has been offering free trips on liners, as "Probationer Engineers," to students taking the mechanical sciences tripos at Cambridge, the object of these trips being to encourage people to take up marine engineering.

This year, the White Star Line followed the example of the Cunard Line, and two Sappers, who had just finished their Cambridge course, were lucky enough to obtain a trip to New York and back on the S.S. *Homeric*.

A complete article might be written on the lay-out of Southampton Docks, and the shore organization that is required to keep a big liner

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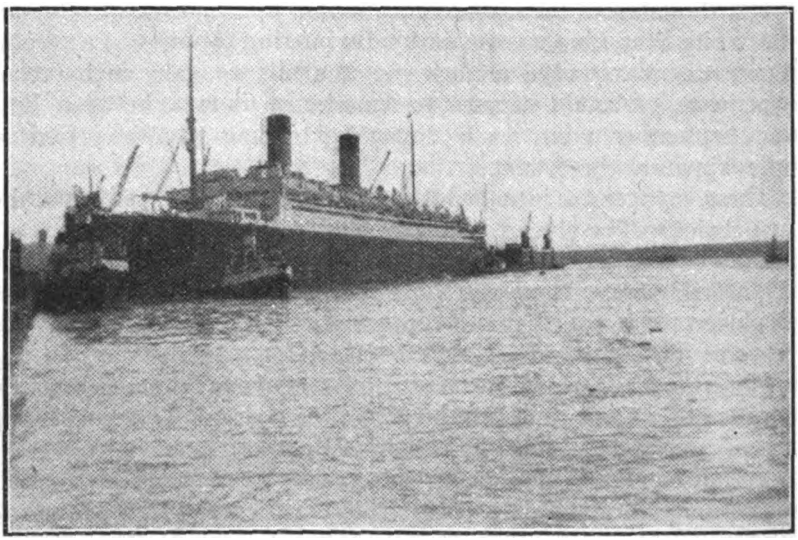
in commission, but the Southern Railway issue an exceedingly interesting illustrated book on the docks, setting out their history, capabilities, and facilities for trade, and outlining the proposed future extensions of the wharf and warehouse areas.

The "Homeric."—The *Homeric* is a twin-screw boat of 34,350 tons, built at Hamburg in 1914. She was laid up at Dantzig throughout the War, was handed over by Germany under the reparations clauses of the Peace Treaty, and was then given to the White Star Co. in compensation for tonnage lost in the War.

Compared to the *Majestic's* 56,600 tons, she is small, and compared



THE "HOMERIC," SOUTHAMPTON DOCKS.

to the *Bremen's* record, her seven days' trip is slow, yet she averages about 19 knots, and from on board seems gigantic.

Deck Plan.—Her size may be gauged from her decks. First, there is the sun deck, which is used for games, and is on a level with the upper bridge. Next comes the boat deck, equal in height to two ordinary decks, and housing the library, the lounge, the tea-room, the smoking-room, and the gymnasium. Below this is the promenade deck, with a wide, closed-in walking space right round the ship. "A" deck is filled by passenger suites and the top of the saloon. "B" deck, the saloon deck, also contains the kitchens and pantries. "C" deck is the last deck above the water-tight bulkheads, and is divided longitudinally by a working alleyway, which runs from stem to stern. Finally, "D" deck is on a level with the tops of the engine cylinders, which stand about thirty feet above the double bottom.

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Engine-Rooms.

Engineer Officers.—The ship carries 35 engineer officers, who keep the watches, and also have to carry out all repair work, since, unlike the navy, the company does not carry engine-room artificers. In addition to the Engineer-in-Charge, there are nine junior engineers on each watch. These are distributed, two in the stokehold, three in the engine-room, the electrician and refrigerating engineers in the auxiliaries room, and the " gang " of two workshop engineers, who are continually kept busy with small running repairs and replacements.

Working Kit.—All wear overalls and boots with wooden pegs in the soles, since it is suicidal to wear rubber on the oily plates in the neighbourhood of the engines.

Engine-Rooms Lay-out.—The engine-rooms lay-out is essentially simple in principle, but is complicated in practice by the extremely limited space.

The boilers are divided into four sections or ranges, two under each funnel, and the main and settling fuel tanks are placed round and between the boiler-rooms. The engine-room is immediately aft of the boiler-rooms and extends right up to the topmost deck level, to allow of easy access for overhauls. Aft of the engine-room the auxiliaries are housed in a low room, which also contains the thrust blocks, and whence the two shafts run down separate tunnels to the stern glands.

Oil Fuel System.—As far as possible, fuelling is carried out at New York, because of the cheaper cost of the oil. Tank barges are brought alongside and their pumps are supplied with steam from the ship's boilers. The oil is pumped through filling stations in the ship's side to a duplicate filling main, which connects through valves to the various fuel tanks. From the top of each tank, an overflow pipe is carried into a duplicate overflow main, a 12-in. pipe, which slopes aft to a sump and through which air is forced by a fan, to prevent accumulation of explosive gases on the tops of the fuel tanks.

Firing System.—For firing, the oil is pumped from the storage tanks to settling tanks, where any water is drained off and where it may be given a preliminary heating before filtering. The oil feed pumps draw the oil from these tanks through a coarse filter, send it through steam heaters, which bring it up to its flash-point temperature, and then deliver it through a fine filter to the burners.

Boilers.—Each of the four boiler sections is in a water-tight compartment, and each section is formed by six boilers, placed back to back, the outer boilers having four burners and the inner boilers three. These boilers were put in before the ship was converted to oil fuel, and are of the ordinary forced-draught Scotch type, with the fire doors adapted to take burners. The superheaters in the smoke

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tubes, which were originally fitted for coal firing, have now been discarded.

Fire Precautions.—Each boiler has an emergency cut-off valve on the oil supply in case of fire, and there are also " Foamite " hand and hose sets to deal with small outbreaks, while larger outbreaks can be quenched by a system of overhead " Foamite " pipes, controlled from outside the stokeholds.

Steam Mains.—From each boiler-room, a separate steam main runs to the engine-room, so that if any stokehold is flooded, the other three may carry on independently.

Boiler Feed.—The main feed from the engine-room is led to each boiler and, in addition, each section has its own auxiliary feed pump for closer control of the boiler water-level.

Engine Control.—Each of the two propeller shafts is driven by a 15,000 H.P. triple-expansion reciprocating engine. The steam lines from the four boiler sections enter the engine-room *via* a cross-connecting main, whence the steam is led through two steam traps to the throttle valves. These throttle valves are moved by a hand lever, connected to a simple steam following gear, or may, in emergency, be moved by a hand-and-worm gearing.

Engine Details.—There are four cylinders on each engine, since the L.P. stages are divided between two similar cylinders, to avoid excessive bulk. The H.P. cylinder has an effective area of 2045·5 sq. in., with a stroke of five feet, has no tail rod, but, in compensation, has an extra thick piston. It is supplied with steam at 205 lb., through a piston valve, which is worked by an ordinary Stephenson link motion, with adjustable cut-off. The I.P. cylinder has an area of 5361·6 sq. in., and the piston has a tail rod and is fitted with special L-section rings, held by springs against the cylinder walls. The exhaust steam from the H.P. passes into the I.P., through a Stephenson link-operated piston valve, at a pressure of 60 lb. The two L.P. cylinders have each an area of 7313·8 sq. in., the pistons have tail rods and have ordinary steel piston rings. The steam enters the cylinders at 19 lb., through " D " slide valves, which are balanced on their seating by exhaust pressure on the back of the valve, and are balanced vertically by equalizing pressure on the under-surface of the valve and exhaust pressure on the top surface.

Reversing.—Reversing is carried out by shifting the link motions of all the cylinders by an armed shaft, that runs along the back of the engine. This shaft is normally operated by a steam following engine, rather similar to a small steering engine, or, if this breaks down, by another small three-cylinder steam engine, which works through the hand-and-worm gear that is provided for emergencies. Full ahead to full astern, with the steam gear, would take about three minutes, or a mile in distance, but with the hand-reversing gear and hand throttle, might take up to ten minutes, and, if there is room, it is

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quicker for a liner to turn in a complete circle than attempt to stop.

Condensers.—The exhaust steam from the L.P. cylinders is led into the condensers through two baffle cylinders, to prevent the hot steam from hitting the condenser tubes in sudden gusts. These condensers are of tube type, through which sea water is circulated by large centrifugal pumps. There is a cross-connection between the two condensers, which can be opened in case of a breakdown. The make-up water is fed into the bottom of the condensers, and about 100 tons a day is used. Air pumps lift the water from the condensers to a tank, from which it falls by gravity through filters to the hot-well. It is then raised to 240°F. by feed heaters, which are fed with the exhaust steam from the auxiliaries, and passes along the feed line to the boilers. There is also a spare line to each boiler section for use in case of emergency.

Propeller Shaft.—The 130 feet of hollow 30-inch propeller shaft is supported by oil-ring bearings every 12 feet. The thrust blocks are of very simple type, consisting of collars on the shaft, which revolve in an oil-and-water slurry against adjustable collars on the blocks. These blocks and the condensers are the two weak points in the German design, both being rather too small for the ship.

Stern Glands.—The ship was originally fitted with German-metal stern glands, but these have now been replaced by lignum-vitæ glands. Each shaft is split up into 30-foot lengths, and may be withdrawn very simply and hoisted through the hatchway of the after-hold.

Lubrication.—Lubrication of nearly all the moving parts is by gravity feed from oil wick reservoirs, which are kept full by the engine-room greasers. Each cylinder is lubricated by a small pump, which forces oil through the cylinder wall at two points. The piston rod is periodically greased by hand, with a brush. The big ends dip into an oil trough, and the main bearings have oil rings. In addition, a sea-water pipe line is led to all important points for emergency cooling purposes.

Engine Duty.—One engineer is always on duty, within reaching distance of the main steam controls and the engine-room telegraphs, which latter are in duplicate and are tested daily. A hit-and-miss type governor is fitted to each engine, but in a heavy sea, it is found better to have an engineer standing by each throttle valve and to dispense with the governors. In fog, there are always extra engineers on watch at the throttles and reversing levers.

Auxiliaries.—The auxiliary room contains the electrical and refrigerating plant, fresh and salt bath-water heating boilers, run off exhaust steam, and an emergency salt-water evaporator.

Electrical System.—The electrical equipment consists of six 140 kw. D.C. generators, 12-pole compound-wound machines, driven by

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double-expansion steam engines at 180 r.p.m. Of these, four are always kept running, since the load, being chiefly ventilation fans, does not alter appreciably by day or night. The switchboard and wiring system is German, pre-war and obsolescent, there being an unnecessary amount of cable throughout the ship.

Refrigerating System.—The refrigerating plant consists of two single-expansion CO_2 compressors, only one of which is used at any time, each of which has its own evaporator. There are three cooling systems. A direct CO_2 expansion line, which is only used for the ice-room. A high-pressure brine line (96 lb. per sq. in.), which is circulated throughout the ship, and which supplies the cold larders, the refrigerated cargo, and the water coolers—of which there are 16 distributed through the passenger accommodation. A low-pressure brine line, which serves the cold-storage rooms.

Pumps.—The pumps in the *Homeric* are worthy of especial mention, as they are nearly all of what might be termed a " general purpose " type; thus one duplex steam pump in the engine-room may, by a system of valves, be made to draw from either the sea, the bilges, the fresh water tanks, or the hot-well, and, similarly, to deliver to the fire system, overboard, fresh water lines, or the boiler feed lines. By these means, almost any pump may be withdrawn from service for repair work without interrupting essential services.

DECK MACHINERY.

Steering Gear.—The steering gear is by far the most interesting part of the deck machinery. The movements of the wheel on the bridge, or the after bridge, are transmitted by a glycerine-and-water hydraulic system, to the steam following gear, situated in the rudder-house. To the top of the rudder post is bolted a horizontal platform, on which is mounted a double-expansion steam engine. The crank-shaft and connecting-rods of this engine are totally enclosed in an oil bath, together with a screw gearing, which drives a pinion wheel, engaging with a fixed toothed arc. This engine runs very silently, but there is unavoidably some play between the pinion and the arc, which gives rise to a continual banging as the water jerks the rudder. For emergency, there is a second engine, which is stationary, and drives the rudder by a large chain, which is fastened to the rudder platform. As a final resort, the rudder could, with a little ingenuity, be worked from two winches, situated one on each side of the rudder-house. An electrical indicator gear shows the rudder position on a dial, situated in the wheel-house, so that the quartermaster can see if the ship is taking weather or lee helm.

Anchors and Winches.—The two bow anchors each weigh seven tons, and each link of the cable weighs more than a hundredweight; the method of anchoring is, therefore, to allow the anchor to drop,

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and the requisite amount of cable to run out and then to snub the cable. The anchor capstan embodies a metal plate clutch, and is driven through screw gearing on the deck below, by a double-expansion vertical engine, which can also be used to drive a cable capstan. Cargo winches and derricks are mounted round each mast, and there are also a few winches on the boat deck to assist in the handling of boats.

Boats.—The boats are mounted in a double tier on roller davits, and are always kept swung inboard. There are also four motor-boats, which are useful when the ship is making its annual Mediterranean cruise.

Wheel-house.—The centre portion of the bridge is roofed over to form the wheel-house, which contains, besides the wheel operating the hydraulic steering telemotor, a wheel connected direct to the steam valve of the steering engine. Here also are the indicator-boards of the watertight doors, and the thermostatic fire-warning system. These indicators consist of plans of the ship, mounted with little electric bulbs, which light up when the doors are closed or the temperature rises above a certain point.

Compasses.—The standard compass is on the upper bridge; there is a stand-by one in the wheel-house, but the quartermaster normally steers from the gyro compass, by a repeater that is mounted in front of him. The gyro compass itself is in a special room on "C" deck, and was made by Sperry. At one time the *Homeric* was fitted with an "Iron Mike," or mechanical steersman, worked from the gyro compass, but it was found that, in all but the smoothest sea, a quartermaster was better, since the machine could not anticipate large waves, and in any case needed a man constantly on watch over it.

Bridge Apparatus.—A gyro repeater, fitted with sights, is placed on each wing of the bridge for taking bearings, where also are situated the engine-room telegraphs and fore and aft mooring telegraphs communicating with the mooring stations.

Chart-Room.—The chart-room opens out of the wheel-house, and contains the ship's chronometers and duplicate electric master clocks, which work electric repeater clocks throughout the ship.

Trim Indicator.—On a passage wall, near the chart-room, is placed a tank diagram and a trim indicator. This is a large level, placed longitudinally and graduated, to show whether the ship is down by the bows or stern. The engine-room is responsible for keeping the tank chart up-to-date, and the bridge, by looking at the trim indicator and the chart, can ask the engine-room to transfer oil or water ballast and so trim the ship.

Wireless.—The wireless-room is near the bridge and has a short-range and a long-range transmitter, worked from power from the engine-room, with a secondary battery for use in emergency. A double loop direction-finding aerial is mounted on the upper bridge,

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but this is still in an experimental stage. The ship is poorly equipped with telephones, there being only the essential communication loud-speaking telephones, and none in the staterooms or passenger accommodation.

Whistles.—The ship's whistles are operated by shuttle valves, worked electrically from the bridge. In foggy weather, there is a clock arrangement whereby the whistle may blow automatically at set intervals.

Ozonizing Plant.—The ship is fitted with an ozonizing plant on the sun deck, and pipe lines lead to all lavatories and bathrooms, but this has been found to be unnecessary and is not used.

Fans.—A deck electrician is always on duty, in charge of the fans. These are nearly all on the sun deck, some exhaust the foul air and others pass fresh air through heaters and down through pipe lines to all parts of the ship. These fans constitute the main electric load.

Deep Sea Lead.—A Kelvin deep-sea sounding machine is mounted on the stern ; this consists of an electrically-driven drum, from which a fine-stranded steel wire lowers a 36-lb. lead. To the lead is attached a long thin tube, sealed at one end and coated internally with a red chemical, which changes colour on contact with water. The pressure forces water up the tube, according to the depth, which may be read by placing the tube alongside a graduated scale. By Board of Trade regulations, soundings have to be taken on approaching the coast.

PASSENGER ACCOMMODATION.

Printing.—A small flat-bed printing machine produces a newspaper, and all menus, daily. It is also used to print any special notices, such as the log extract, but cannot cope with very large work.

Cinemas.—There is a full-size cinematograph screen with two projectors in the saloon, and other smaller ones in the second and tourist classes. The projectors are electrically-driven, with a magnetic change-over device to ensure continuity of projection.

Lifts.—British Waygood lifts with the motors at the bottom of the shaft were installed by the Germans, and serve the 1st and 2nd class passengers. The automatic luggage lifts are a German make with the motors up above.

Cold Rooms.—The food cold rooms are divided up to take the different types of food, at the different storage temperatures required. The coldest room is used for the storage of ice-cream, which is not made *en route*, but is shipped before each voyage. Fresh milk is stored in small urns at a slightly higher temperature, and usually remains fresh for the seven days of the crossing. Poultry, game, meat and vegetables, each occupy other rooms, and a lift is provided to take the food from the cold rooms to the galley.

Galleys.—Food brought up from the cold rooms is gradually thawed in cold larders, and is then prepared for cooking by electric

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potato-peelers, vegetable-washers, mincing machines, dough-kneaders etc. The galley ranges and ovens are all heated by electricity, and electric hot-plates keep the food warm at the serving hatches. All plate-washing is done in electric machines of a spray type, which are found to be more economical in water than the immersion type.

Provisioning.—Under the chief steward are stewards responsible for accounting for, and forecasting, the provisions used, and required, on each trip; the quantity of linen needed, and the stock of liquor. These requirements have to be completed a day before the ship docks, and are indented for in advance by wireless, so that they may be ready and save delay on arrival.

Summary of Trip.—From the personal point of view, the trip was great fun, as an unusual experience. After two years of theory at Cambridge, contact with practical engineers, and their difficulties and methods, was very refreshing. A ship's engine-room is like a giant power station, which must be kept going at all costs, and the organization and supervision needed to ensure this smooth running is very instructive.

The description of the vessel that has been given is an incomplete picture of the trip, since the most interesting parts of the voyage were experiences which cannot easily be reproduced on paper.

Thus, for example, at the S.M.E. workshops, and at Cambridge, one was always told that the first remark to make on meeting a boiler was: "What weight of steam does it evaporate per hour?" This question was tried, timidly enough, on the junior sixth engineer. The shock which was received, when he answered that he had not the least idea, helped to temper the successive shocks when neither the senior third, nor the second, nor even the chief engineer himself, could answer the question.

Similarly, the dryness fraction of the steam entering the H.P. cylinder was unknown. All that mattered was that the engines should run smoothly, and that there should not be too much priming in a head sea.

The engineers are all very good fellows, knowing nothing of entropy or internal energy, but able to tell the condition of a bearing by an applied thumb, or the exact health of an engine by ear, and physically fit to stand eight hours' work every day, Sundays included, in a temperature that averages 108°F., and in some jobs over the boilers, may reach 160°F. In foggy weather, anyone may have to stand an extra four-hour watch, besides his own two watches, and in case of breakdown, or when entering and leaving harbour, everyone has to be in the engine-room.

The lighter side is presented by the trick of crawling under the auxiliary room plates, and rattling a hammer against them in time with the beats of one of the high-speed dynamo engines, with the result that the electrician on duty is nearly driven crazy in trying to

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find out whereabouts in the room the odd noise is, and what it is that has gone wrong.

A rap with a metal bar on the gong of the engine-room telegraph also produces astonishing results, if the back of the engineer on duty at the controls is turned.

A fast and furious game of football in the small engineers' changing-room gives relief after a four-hour watch, while everybody occasionally gets ducked, fully-dressed, in the bath, starting usually with the senior engineer of the watch.

The tales of the engineers are impossible to reproduce, since they need to be told while sitting on a thrust block, transmitting some 15,000 H.P., or standing in the draught of the ventilator between the two engines, and they must be constantly interrupted by short pauses, to verify gauges or to thumb the bearing of a big-end weighing five tons.

Practical experience gained on the trip varied from a method of making ordinary cement into quick-setting cement for small jobs by adding soda, to a working knowledge of the ineffectiveness of prohibition in America.

One of the greatest inducements for making the trip was the prospect of seeing New York, and the unusually short stay of only twenty-five hours had to be very crowded. A letter, written by the author, will give the best idea of the visit.

"... I went to a midnight cinema show on arrival, travelling up-town by express and local subway, exactly as described by General Parsons, in his lecture at Cambridge, last term. The cinema was cool, well-ventilated, and the 'talkie' reproduction was 50 per cent. better than in London. An added touch of care for the patrons' comfort was the free presentation of a morning paper as one left the cinema.

"I slept at a hotel, and the next morning went over the New York Stock Exchange with a friend, the youngest member on the floor. It is very well worth a visit, and I now know the true meaning of the word 'babel.'

"I then went up the Woolworth Building, 57 floors, and the lift does not stop till the 36th. The view is magnificent, but the surrounding architecture is atrocious, since the true massive plain style for skyscrapers is only just starting, and the older buildings vary in styles from the Egyptian to a florid Gothic.

"I lunched in a City club (cocktails were ordered before the meal, just as simply as in any club in London), and then went up-town by elevated to shop. Then on to the residential quarter on East side, to friends, where I saw the interior of a typical New York private house, cool and comfortable.

"These friends took me out by car over the Long Island suspension bridge (four lines of cars in one direction, two in the other, all crawling across at about 10 m.p.h., in a traffic block a mile long), by main

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roads, which at their best were perfection, and at their worst had tramlines sticking up four inches above the surface. We went to a country club, complete with tennis courts, a golf course and a swimming pool, that lay immediately in front of the broad, shady verandah. Here we dined, and after dinner, I returned by train (complete with headlight, cow-catcher and conductor) and caught the ship.

"The Americans are essentially a practical nation; where we put up a notice 'Wet Paint,' they simply put up 'Paint'; if you feel hot in the subway, you take off your coat and hang it on a peg, if you still feel hot, nobody will object if you add your collar and tie. Every store and hotel lobby is fitted with a water cooler, whence you may obtain iced water in a paper cup.

"They are a gregarious nation, and seem incapable of entertaining themselves, but have to be in a crowd. Finally, that they are a persistent nation, is shown by the fact that the statue of Liberty was pointed out to me as the statue of Liberty no less than forty-five times, as we sailed up the harbour."

Hints for the Trip.—A few hints for others making the trip. Make firm friends of the pursers and the chief electrician; the pursers can move one into a comfortable cabin and the chief electrician can supply a fan. Whatever may be said to the contrary in the instructions, it is advisable to take a dinner-jacket, since all the first-class passengers change for dinner. Finally, cool clothes should be taken, as New York in the summer is very hot.

The trip as an experience was invaluable as, in an army career, it probably provides the only chance of visiting America.

VIEW FROM THE WOOLWORTH SKY SCRAPER.

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THE PERMANENT DEFENCES OF SHANGHAI.

By LT.-COLONEL L. E. BARNES, O.B.E., R.E.

WHEN the Defence Force first arrived in Shanghai, at the beginning of 1927, their problem was to keep outside the International Settlement the warring Chinese factions, namely, the Northern and Southern Armies. To this end, barbed wire entanglements were erected, across fields, along creeks, in streets, up alleyways—in fact, all along the Settlement boundary and round the residential area to the west of it; it was even necessary to continue these barriers between the International Settlement and the French Concession (*vide* Plate I), as it was doubtful at that time whether the French preparations were adequate to prevent the ingress of Chinese troops. In all, 16½ miles of wire were erected, and, in addition, some houses were fortified and many breastworks, little blockhouses of concrete slabs, sandbag emplacements for machine-guns, etc., were constructed, all of which formed strong points along the perimeter. The principal danger was anticipated from the open country to the west, as the Cantonese forces were approaching Shanghai from that direction.

As time went on, the theatre of civil war moved northwards, the French defensive arrangements on their south and west boundaries were improved, and the situation generally became less tense. By degrees, the temporary defences on those parts of the perimeter which lie in open country were removed, or, in places where the removal was not worth the cost of materials, left for the local Chinese to take away.

The passing of the Southern, or Cantonese, Army, however, left a virulent form of Communism in its trail. As is well known, the Cantonese forces had been enrolled and instructed in Communistic principles, and they had Russian Bolshevik officers on the staff. It would have been hard to find a more receptive outlet for their nefarious energies than was provided by the thousands of illiterate Chinese coolies and mill-workers of Shanghai, already somewhat tainted with Bolshevik teaching; the Communist leaders were not slow to grasp the opportunity thus offered to them, and they fanned the fires of discontent and disorder with great advantage from their own point of view.

Thus the danger to Shanghai was no longer to be anticipated externally from organized Chinese forces, but internally from dis-

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THE PERMANENT DEFENCES OF SHANGHAI.

PHOTO (*a*).—Some original defences at "B" on Plate II, from the Settlement side.

PHOTO (*b*).—As Photo (*a*), but from the Chinese side. The sentry shown is a Cantonese.

These two show a concrete slab blockhouse, a gate made of barbed wire on a wood frame, and a sloping screen of expanded metal to catch bombs.

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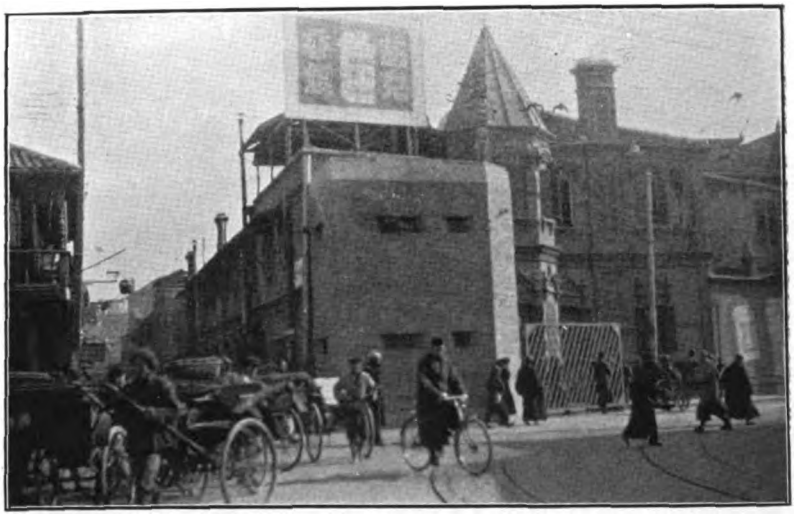

PHOTO (*c*).—The modern blockhouse and steel gate which have replaced the defences shown in Photos (*a*) and (*b*).

PHOTO (*d*).—Blockhouse "E," just beyond the cross-roads of two narrow streets. It is raised on a framework of reinforced concrete, and the caponier gives facilities for firing up and down the street at right angles to the one in the photo.

Chapei is in the background, and a steel gate can be distinguished under the centre of the blockhouse.

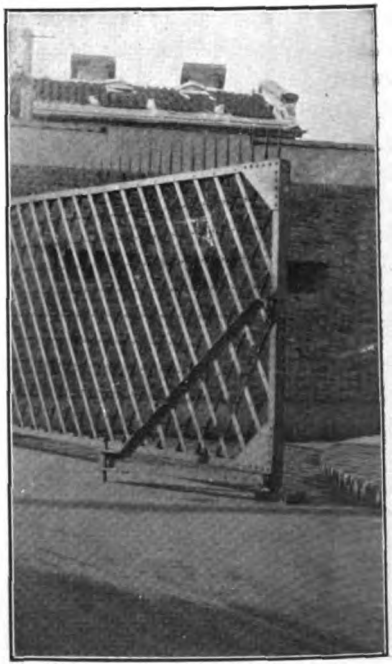

PHOTO (*e*).—The moveable end of a steel gate, showing the drop-bolt and the bracket which puts it out of reach of the mob.

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organized mobs, and the probable scene had shifted from the open country to the narrow streets of the Chinese part of the town.

In order to follow the development of the situation, it is necessary to bear in mind the broad outline of the geography of the place. In Shanghai, as a whole, there are two densely-populated districts outside foreign control, namely, Chapei and Paoshan to the north, and the Chinese City and Nantao to the south, and these two are the potential centres from which Communistic danger threatens the foreign settlements. The southernmost of these need not be further considered here, as the French Concession, with efficient defences, police and troops, lies between it and the International Settlement.

Now the International Settlement has a population of 857,000, of whom 824,000—about 96 per cent.—are Chinese. It also has an armed and well-trained police force of some 3,800, of whom 450 are British, 100 Japanese, 800 Sikh, and the remaining 2,450 Chinese, principally from the North; this force, well served by an excellent C.I.D., is fully able to quell, in the early stages, any mob which might try to collect within Settlement limits. But the police cannot deal with a mob collecting outside the Settlement, until it attacks or comes within the boundary, by which time it will have attained alarming proportions, and thus it comes about that the Chinese-controlled district of Chapei and Paoshan is the serious danger-spot for the Settlement.

Till the end of 1928, the original barbed wire entanglements and concrete blockhouses still existed along this part of the perimeter. They greatly impeded traffic in the narrow streets, and caused much inconvenience and loss to the small shopkeepers, whose shops were thereby cut off from the streets and whose trade was consequently impaired; many applications and petitions for removal of these obstacles were made to the Shanghai Municipal Council. From the military point of view, these temporary defences required replacement by something more permanent; the wooden posts for the wire entanglement—no screw pickets were available when they were erected—were unsatisfactory, being liable to rot, and the concrete blockhouses were very elementary in construction, being neither bullet-proof, weather-proof, nor equipped with drainage or any conveniences for fighting or for comfort.

Headquarters, North China Command, therefore represented to the Shanghai Municipal Council that permanent defences should be provided without delay, so that the reduction or entire withdrawal of the garrison might not leave Shanghai as unprepared as it was in 1927. A committee was accordingly formed, with the Commandant, Shanghai Volunteer Corps,* as President, the Commissioner of Police,

* The S.V.C. is under the direct control of the Shanghai Municipal Council, the ruling body of the International Settlement. The Commandant is a Regular Officer, of the rank of full Colonel, lent by the War Office and changed every 3 to 5 years: he is, *ipso facto*, the expert adviser of the Council on all military matters.

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and a representative of the Public Works Department of the S.M.C., as members, and the C.R.E., North China Command, as technical adviser. This committee put forward recommendations for a total provision of eight blockhouses, thirty steel gates and a few lengths of permanent barbed wire fencing on steel uprights, all of which are shown on the attached plan. The Council approved of this, allotted the necessary funds, and the work has recently been completed.

Briefly, the principle which guided the committee was that mobs are not dangerous unless they can move unimpeded down streets or wide alleyways: any obstacle, such as a creek, or a narrow alleyway leading to only a few houses, though not insurmountable, will suffice to break up a mob, and will, therefore, rob it of the power to do serious damage. Based on this principle, the scheme submitted by the committee put a steel gate at every bridge, road and large alleyway leading from Chapei and Paoshan into the Settlement, and, to support this defensive line, sited blockhouses where tactical considerations showed them to be necessary—always bearing in mind the experiences of 1927. Where possible, the gates were located on the Chapei side of those roads which run parallel to the boundary, but, in places where the boundary actually runs along the road itself, it was necessary to put the gates across the Settlement roads leading therefrom. The detail is shown on Plate II.

Naturally, this defensive line was made strongest in the centre, but it extends far enough to the east to cover all the main roads leading into Shanghai from the north, beyond the limit of the disturbances of 1927, and far enough to the west to cut off, from the residential part, the mill area along the Soochow Creek, where Communist troubles have been known in the past and are quite likely to occur in the future. The second line, giving depth to the defence, is provided by the Police Stations themselves: this is a convenient arrangement, as the police will close the gates and occupy the blockhouses in the first instance, and will only be relieved by the Volunteers if the situation becomes so serious as to demand that measure.

Some details of the blockhouses and gates are shown on Plates III and IV, reproduced by the courtesy of Mr. C. Harpur, Commissioner of the Public Works Department of the S.M.C., and the photographs serve to illustrate the mode in which the work has been carried out.

The blockhouses are, generally, of brick with walls 20 in. thick, provided with loopholes and platforms for machine-gun and rifle fire: each loophole has a $\frac{3}{4}$-in. steel plate to close it, and the sliding door is of similar material and design. They are provided with arm-racks, shelves and pegs, furniture and latrine arrangements; water and electric light are laid on, and an observation post, in which one

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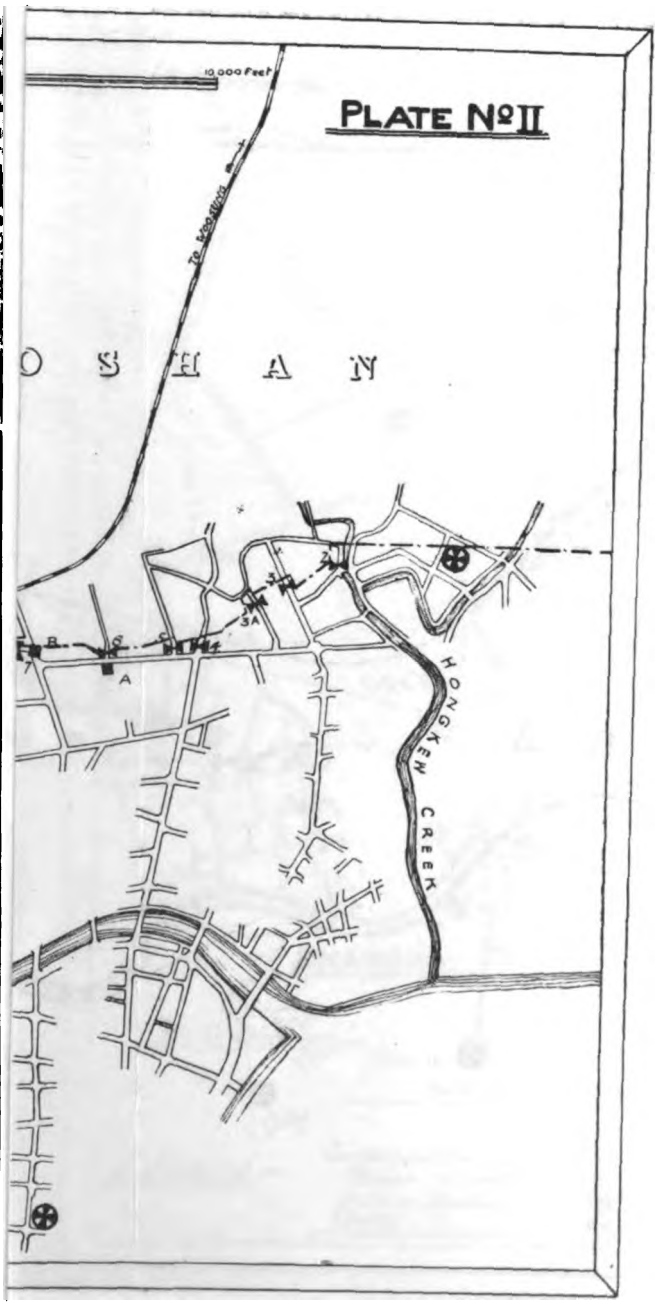

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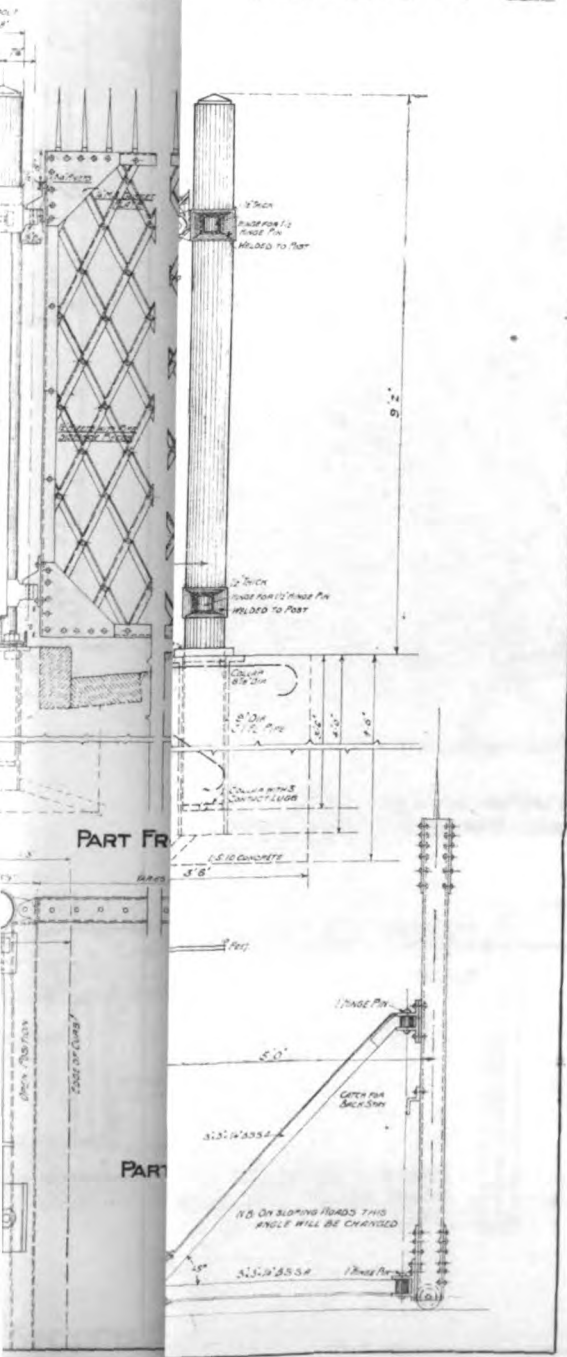
DEFENC PLATE Nº IV



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man can keep a look-out over all avenues of approach, has been added recently: further, each blockhouse has direct telephonic communication with the Central Police Station, and this can be switched over to the Headquarters, Shanghai Volunteer Corps, if and when the defences are handed over to them.

Some blockhouses are single-storied, and some are double-storied, whilst one is at such a narrow cross-roads that it has been necessary to raise it on pillars so that all traffic can pass underneath: two others are of "mushroom" design, being steel cylinders raised on a single central pillar above the traffic. The cost averages taels 1,500 (£200 approx.) per blockhouse.

The gates are 9 ft. 6 in. high, of ½-in. channel steel, laced together by ¼-in. angles in a lattice-work design. They can be shut by one man, and a neat arrangement of brackets ensures that the drop-bolts, which keep the closed gate in position, are out of reach of the mob on the far side. Bullet-proof gates of steel plates were found to be too heavy. The cost of these gates averages taels 700 (£100 approx.) each.

Thus the Settlement is now well defended in the centre of her boundary, but has nothing whatever on either side. If armies advance on Shanghai again special measures will once more be required in these open parts of the perimeter, with mobile forces and field defences as necessary; but it is to be hoped that this is a very remote contingency. The ever-present danger is to be found in the Communist efforts, and the permanent defences described above should greatly reduce this menace to the safety of Shanghai. In fact, it is by no means unlikely that the very existence of these defences will nullify the best efforts of Bolshevik orators to send others on the dangerous mission of doing violence in the Settlement. If this proves to be the case, then the outlay on this visible and tangible form of insurance is an expenditure which the Shanghai Municipal Council will never have cause to regret.

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A TWENTIETH-CENTURY SPORT.

By CAPTAIN C. A. DE LINDE, R.E.

IT is only fit that the Journal of a Corps so diverse as ours should have reflected the catholicity of its readers in publishing, within the last few years, articles on the great sports of hunting, sailing, mountaineering and travelling. This century has seen the coming of age of another sport; a sport that can vie with fox-hunting itself in bringing out the military virtues and in giving its followers the most pointed pleasures of the open air. A belief that, in these respects, it need not shrink from comparison with any other sport whatsoever must be my excuse for writing about ski-ing in this place.

Ski-ing, which to-day we are apt to think of as a mountain sport, was born in the rolling country of the Lapps as a most utilitarian means of locomotion. For a thousand years it was nothing more and nothing less, till about 1880 the Norwegians began developing it as a sport; later, it was introduced to the more precipitous Alps of Central Europe; to-day, the sport has spread over almost the whole mountainous world. It is natural to ask how this sudden and ever-increasing popularity of ski-ing has come about. Thomas Cook, The Swiss Hotel Proprietors' Association, the Southern Railway, may, singly and collectively, have had something to do with it. The crowds, fumes and noises of an ill-adjusted civilization have undoubtedly made twentieth-century man—and woman—turn more and more to open air holidays. But above all it is the innate merit of a holiday in the snows that has made ski-ing so popular. First, there is no healthier holiday; one spends the whole day in air that Margate itself cannot rival for purity and bite. Not only is there this bracing air but, possibly even more provocative of health, there are the unabated rays of the Alpine sun. To go to the mountains in winter is one of the few practical methods open to twentieth-century man of getting away from the sound of a motor-horn and the stench of exhaust gases. Then there is the matter of scenery; there may be those who prefer the wild waste of waters, the peace of Suffolk's "lilied lowland waters," or the quiet greens and browns of the Shires, but no one will deny the noonday majesty of the Jungfrau, the magic of sunrise against the Wilde Kaiser or the ethereal loveliness of a larchwood under the tracery of snow. So much for outward circumstance. For the running itself, it is not just a matter

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of sliding and falling down a slippery slope; there is the zest of speed, the thrill of succeeding, at the tenth time perhaps, in doing a turn just a little faster than you have ever done it before; the effort, a painful joy, of bracing yourself to take a slope straight which dull caution would have you traverse; the excitement of the start down to the road which you see four thousand feet below you; the thought of the hot rum that you will order at the Schwarzer Adler further down that same road; the satisfied fatigue of the hours between dusk and bedtime.

Ever since the Peninsular War, it has been a tradition in most branches of the Service for commanding officers to give every encouragement to officers desirous of hunting the fox. Even in a mechanical age, excellent reasons can be found for continuing the tradition. In the same way, there is much to be said for encouraging officers to go ski-ing. I believe I am right in saying that this is a definite policy in the Royal Air Force. Leaving aside these amiable generalizations, we can now consider what are the attributes of this sport that make it one particularly suitable for our martial selves. First of all, it inculcates the hotch-potch of virtues which we call "dash," sound judgment combined with quick decision, boldness held in light restraint by caution. In a single day's run, you will be called upon a dozen times to make decisions; the quicker you make them the less likely you will be to get into trouble. Unless you are quite mad, you will never ski alone, and the presence of companions will always stimulate you to take the bold course without taking the foolhardy one which may involve their *carrying* you down, painfully and slowly. To make a good decision it will be necessary to take in the country at a glance. There is much to take in: snow conditions (there are at least half a dozen varieties of snow, most of which you may meet within the space of half an hour), rocks and boulders, cornices and avalanche slopes, fences and gates, trees and half-hidden bushes, ditches and sunken roads, and, as troublesome as any, every change of gradient. Your eye for country is being constantly exercised. This is not only the case while you are running down, but also while you are climbing; few things are more exasperating than a leader laying a bad track. To no one is the contour less of an abstraction than to the skier on his ascent. It is scarcely necessary to point out how essential in war is an eye for country. A small fold in the ground that has been seen and noted may turn failure into success; no one is more likely to note it than the ski-running man. Again, weather is often a factor in military appreciations; to notice weather conditions becomes second nature with the mountaineer and ski-runner. His life, like that of the soldier, may come to depend on weather wisdom.

It will not be inapt to quote here the following from the *British Ski Year Book*, 1927: "On December 12th, 1916, snow began to

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fall and fell continuously for a fortnight [on the Austro-Italian front]. Colonel Bilgeri had drawn the attention of the Authorities to the precarious situation of various Alpine Barracks, but his warnings were disregarded. During this fortnight, no less than 3,000 of the 80,000 men in the Higher Alpine Stations were killed by avalanches. The Italians suffered even greater losses." Comment is superfluous, the moral obvious.

Map reading is one of the minor military arts. There is not much to choose between the difficulty of reading a map in a devastated forward area and that of reading it in a desolation of mountain peaks shrouded in mist. Both tasks may be impossible; but if you can do one you can do the other. A map and a compass are as essential for serious ski-ing as for real war. Lastly, to digress from the particular to the general. In any sort of cross-country ski-ing, there must be a leader, and on the capabilities and character of the leader depends often the enjoyment and success of the expedition. So, in this particular form of sport, there lies an excellent way of practising the art of leadership, to a soldier the most essential of all arts.

To get the best value out of ski-ing, one should never stick to one centre or even one country. An idea is prevalent in England that ski-ing means Switzerland. It most emphatically does not. The more an officer knows of foreign nations the better. If he goes to the more obvious places at the more obvious times, the Oberland, in January, for instance, he can no more claim to be seeing a foreign nation than the man who winters at Cannes can claim to being a traveller in France. The Alps take their rise in France, however unfashionably, and at Grenoble and Briançon, you will be able to see the Frenchman at home and, if you go about things the right way, you may even be able to go ski-ing with those fine mountaineers, the Chasseurs Alpins. Then south of Switzerland, the Alps spill over into Italy, and the Italian enthusiasts will be met in great numbers at Cortina, amongst other places. East, the Alps run almost to the gates of Vienna. In the Silvretta group, ski-ing is practicable as late as June. Colonel Bilgeri, the great Austrian expert, organizes week or ten-day tours every year in various parts of the Alps, and is always very good in taking English people who have provided themselves with an introduction to him. Germany can boast ski-able mountains in Bavaria. Then the Carpathians run through three countries, Czecho-Slovakia, Hungary and Poland. Only last year the Czech military authorities issued a special invitation to British officers to attend their ski school. Lastly (I write here only of Europe), there are the two countries of Norway and Sweden, for the wise runner who looks for fresh snows and mountains new. It is safe to say, without having visited all these lands, that the man who visits them armed with ski will come to

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know more of them and their peoples than ever would the mere tourist, however much his pockets bulged with Cook's coupons and circular tickets. There can be no denying that an enthusiasm shared is an introduction that will open the most reserved heart; the natural freemasonry that has always existed between horse-lovers is only equalled by that between mountain-lovers.

It is too commonly thought that ski-ing is an expensive sport. It certainly can be, but it equally certainly need not be. It is not necessary to stay in the Grand Babylon Hotel; nor to buy your kit in Savile Row; nor to lounge expensively over the bar. It is possible and not unamusing to drink the beer of the country; to use up your old uniform—dyed blue for preference; to take a room in the village—in the home of a guide, if it may be; to travel less expeditiously, but perhaps as serenely, in a train equipped with second-class accommodation. To take an example, a month at a place like Briançon need cost you no more than £20 to £25 when once you have attained to some wisdom in foreign travel. Even an agency will quote prices which work out as low as £5 10s. per week (to this must be added equipment, club, lessons or guides and incidentals included in the first figure).

It is a platitude, but nevertheless true, to say that the British Army may be called upon to fight anywhere, and at any time. In the last war, British troops were to be found in the Trentino Alps, in North Russia, and on the snow-covered plains of Siberia. It would have been fantastic in 1910 to think of British troops advancing up the Struma Valley, of a British General receiving the keys of Jerusalem, of a British rest camp at Faenza, in the heart of Italy. Is it so fantastic to think to-day of a campaign among, say, some of the mountains that radiate from the Pamirs? France has her school of mountain warfare at Briançon; the Norwegian, Swedish, Czecho-Slovakian, Polish, Japanese, Italian, German, Austrian and Finnish armies, all have units specially trained to winter and mountain warfare. Our defence problems are different and we obviously could not afford any specialized unit, even in India; but it might be profitable for authority to look in future on ski-ing with the same benevolent eye that it has in the past turned on the sport of fox-hunting.

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*THE FORCING OF THE SAVE AT SCHABAZ BY THE AUSTRO-HUNGARIAN ARMY, AUGUST 12th–24th, 1914.**

By LIEUT.-COL. DR. OSKAR REGELE, *of the Austrian Army.*

THE subject of forcing rivers is steadily increasing in importance, since, through the development of technical science, obstacles on lines of communication are being gradually eliminated, and mountains and rivers will soon be the only effective obstacles. This has already been fully illustrated in the course of the Great War. The crossing at Schabaz, in Serbia, in 1914, is amongst the most instructive and important forced passages effected by the Austro-Hungarian Army.

Schabaz, a town which, at that date, had a population of 14,000, stands on the right bank of the Save, on the southern border of the Matschwa plain, and is an important point of communication. On the northern bank a railway runs to the Save, and several roads, as well as a railway line, connect Schabaz, which is also a river port, with the interior of Serbia. Considered as a crossing-point, the town presents several disadvantages. It is situated on a sharp bend of the river and therefore presents great tactical disadvantages for the site of a bridgehead on the southern bank. These are intensified by the fact that the hills situated to the S.E. of the town, near Mischar, command the crossing-point, whereas there was no favourable spot in the immediate vicinity of the town, owing to the thick undergrowth. But the occupation of the hills above-mentioned for the protection of the bridgehead would have entailed a dissipation of effort, and was, therefore, almost out of the question. The breadth of the river is about 650 m., and at the normal level the depth is 2 to 2½ m. Its current is 1 to 1½ m. per second. The banks are of moderate height, of a soft soil, of which the river-bed is also formed.

The plan of the Austro-Hungarian H.Q. Staff was a march by the 5th and 6th Armies from Bosnia, across the Drina, to Serbia. In order to support this difficult operation, the 2nd Army, which had advanced to the Save and the Danube, was to hold up Serbian forces by local attacks across the Save at Mitrowiz and Schabaz, while feint crossings were to be made east of the latter. The outline of

* (1) *Oesterreich—Ungarns letzter Krieg* 1914-1918. Vol. 1, Vienna, 1929.
(2) *Schabaz* by Feldmarschall-Leutnant T. Schön, Reichenberg, 1929.
(3) *Les Victoires Serbes* by Desmazes and Laumowitsch, Paris, 1928.
(4) *Tagebücher des Verfassers.*

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this plan clearly shows the strategic importance of Schabaz, and the importance of the successful crossing planned for this point. From the first, however, this scheme was doomed to disappointment, since it was known that the 2nd Army could serve on the Serbian front for a short time only, as it was to be transferred to the Russian front. The 2nd Army could not, therefore, undertake any operation on a large scale, which decidedly hampered the decisions of the commanders. For this reason, the operations at Schabaz were an extremely doubtful proposition, and made the heaviest possible demands upon both officers and men. It was, undoubtedly, a very difficult problem to cross a broad river, within view of the enemy, and to hold up strong enemy forces, whilst at the same time guaranteeing the possibility of an immediate withdrawal of our own troops to the northern bank at any moment.

Whereas six battalions of the 29th Infantry Division crossed to the southern bank at Mitrowiz and Jarek, on August 12th, without special difficulties, engagements took place on the same day at Klenak, where a " demonstration with Infantry only, unaccompanied by horses," took place ; which was the prelude to a thirteen days' battle around Schabaz. The following units took part in the first crossing : the 62nd Brigade, under Maj.-Gen. von Dani ; the 44th Infantry Regt. ; and the 5th Pioneer Battalion, with 18 bridging columns. After a march of 32 km., on August 11th, the Pioneers reached Hill 81, north of Klenak, after sending forward mounted reconnaissance officers to the Save. Between 5 and 7 p.m., artillery fire was directed upon Schabaz, in order to warn the enemy of the commander's intention, since this was of the nature of a demonstration. The first crossing was so organized that, during the night of August 12th, the 1st, 2nd, 3rd and 5th Companies of the 5th Pioneer Battalion, with three bridging columns each, marched over the concrete bridge (3) to the bank, where they prepared pontoons for the attack. The bridging wagons moved off across the military bridge (2), constructed during the night, back to Hill 81. The pontoon groups were separated by two sunken vessels (10), so that on the right flank, the 1st and 2nd Companies—and south of these, the 3rd and 5th Companies—occupied their positions in observation. Each company had 18 pontoons, which were to be sent in three successive bounds of 6 pontoons each. Each company in each bound included 160 infantrymen. The night of August 12th was moonlight ; preparations were not disturbed by the enemy, and only a few stray shots were fired. The 44th Regt. were brought to the wooden bridge (4) by Pioneer commanders, and by 3 a.m. had embarked in the pontoons. At 3.10 a.m. came the order for the attack, and the first bound of all four Pioneer Companies left the bank immediately. Silently they rowed out into the river, and reached the middle unopposed. There, they were suddenly attacked

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by the fire of the Serbian forces on the bank, and fell into disorder. In the confusion of the engagement, the various pontoons were left entirely to their own resources. Many mistook the direction, and began to drift; others could not complete the crossing, and turned back. The 2nd Pioneer Company alone, with units of the 1st Company, succeeded in landing their infantry—in accordance with orders—on the enemy bank, and in returning to their own post with few casualties, in spite of hostile fire. Here it was already assumed that the first crossing had failed, but the empty pontoons of the 1st and 2nd Companies dissipated the fears. General transportation was at once continued, and at daybreak, 5.15 a.m., the whole of the 44th Regt.—four battalions—had reached the southern bank. There was some friction due to the fact that the infantry did not come up quickly enough, and so checked the transport arrangements. The heaviest casualties occurred amongst the troops and the teams of the bridging columns assembled on the northern bank, whereas the troops ferried across quickly reached the dead ground of the southern bank, and were therefore soon under cover. The ferrying was continued, a battalion of the 32nd Regt. followed, and towards noon, a battery of the 10th Field Artillery Regt. transported in sections. At 3 p.m., Gen. von Dani took Schabaz from the north, with these troops. The Pioneers started for Schabaz at 4 p.m., with their entire equipment, and immediately constructed two landing-stages on each bank (11 and 12). Half of the 1st, 2nd and 4th Pioneer Companies remained during the night—as ferry reserve—on the south bank, and maintained communication with the Infantry. At the bridgehead, fairly frequent fire was maintained against the enemy, who were endeavouring to gain contact, and the embarkation position was also under fire.

On the Serbian side, there were, on August 12th—on the bank at Schabaz—two Infantry Companies, with two guns, as well as customs and gendarmerie detachments. One company was at Mischar, and in the immediate vicinity of Schabaz there were also four battalions and one squadron. In spite of this garrison—sufficient for the defence of a large river—the Serbian Reserves did not intervene in the engagement, but withdrew in the direction of Mischar, in consequence of the effects of artillery fire from Tursko Groblje. Owing to this action, the first and the best opportunity of driving back the landing parties into the water was lost, and the attacking party gained an important initial success.

On August 13th, ten ferry units of the 5th Pioneer Battalion, assembled on the previous day for transport, were taken across on simple pontoons—the crossings continuing up to 8 p.m. In addition to the horses and trains of the fighting units already in Schabaz, three composite battalions (third line), artillery and Pioneer columns, with entrenching tools, reached the south bank. Since no motor-

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boats were available, parties of Pioneers were obliged to row across the broad river. On the return trips, the wounded were brought back. During the day the first steam ferries arrived, which decidedly accelerated the passage (13). At first, it was composed of one steamer with two, and another with four, towed boats. The two monitors, *Marosch* and *Leitha*, afforded great protection at the crossing-point; built in 1871, they had been in action together in 1878, at Brod, on the Save, co-operating with the 5th Pioneer Battalion. They were indeed obsolete (310 tons, 50 m. in length, 8 m. in breadth; armament: one 12-cm. gun, two 47-mm. Hotchkiss m.g's., one 8-mm. m.g., armour-plate, sixteen 50 mm.; two screws; draught, 1·2 m.), but did excellent service in the battle of Schabaz. In order to establish continuous communication with Schabaz, and in the absence of special means of communication (aeroplanes, wireless, river-cable), 20 pontoons were anchored, on August 13th, straight across the river above the crossing-point, and a telephone line laid over them.

Gen. von Dani occupied the outskirts of the town, and repelled the first Serbian attacks from Mischar. The Serbian 3rd Army gave orders for the recapture of Schabaz, on August 14th, and dispatched the Schumadia 1st Division for this purpose. Since the Austro-Hungarian troops in Schabaz were forced to take the offensive, Gen. von Hortstein—who was now in command in Schabaz—formed an attacking force, composed of the 29th Division, and various units of the 7th Division, which was to assemble in Schabaz. The small demonstration carried out by the 44th Regt. at Klenak had now already developed into an important action. During the night of August 14th, the 1st, 2nd and 5th Pioneer Companies—the latter making use of the steam ferry—remained on the south bank, where, by raids, they maintained communication with the Infantry, and at 11 p.m., also took an active part at the steamer quay in repelling Serbian attacks. The demonstration of the 29th Division at Mitrowiz and Jarek was ineffective. At Belgrade, the Zigeuner Island was occupied.

The first important attack of the Serbians upon Schabaz opened on August 14th. Transport had been continued during the entire forenoon, the 5th Pioneer Battalion received orders—towards noon—to prepare in Schabaz to launch a military bridge, since ferrying alone was inadequate, and the troops on the southern bank were steadily increasing in numbers, and needed a safer means of communication between the banks. Preparations had just begun on both banks, and the bridging columns were about to unload the equipment on the north shore, when the enemy opened heavy artillery fire, surprising the bridging column, and forcing it to retreat and take cover. Shortly afterwards, the Pioneer Companies on the right bank received orders to prepare without delay to intervene

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in the battle behind the bridgehead on the left flank, where the 52nd composite battalion was hard pressed by the enemy, and, in any case, to keep in touch with the retreating Infantry, until reinforcements arrived. Meanwhile, the 53rd composite battalion was ferried to Schabaz under artillery fire. After this battalion reached the fighting line, the Pioneer Companies were withdrawn from the engagement and assembled on the left bank of the Save, to launch a bridge which was to be completed by 5 a.m., August 15th. But continuous artillery fire from Mischar, as well as infantry fire, interfered with the bridging work, which was, therefore, postponed to the following day. The Serbian attack had opened at 10 a.m., with ten battalions and four half-squadrons, with the object of capturing Schabaz from south and east. The Serbians reached the outskirts of the town, but were repulsed by the eight battalions of the defence, all reserves being brought into action; artillery also co-operated from the north bank, and very effective support was received from both monitors. By the later intervention of a force, under Gen. Letovski, which had marched through the Matschwa, and appeared before Schabaz at 1 p.m., the Serbians were forced to withdraw across the Dobrawa. A panic which occurred amongst the men of the train, together with numerous casualties, once more made great demands upon the Pioneers (especially at the steam ferry), since parties of the train had to be taken back to the north bank. Gen. Letovski took over the command in the town, from Gen. von Dani, who was wounded. The Schumadia Division I, which was moving up by forced marches, could only bring two of its sixteen battalions into action; this enabled the defence at the bridgehead to gain a fine success. The attempt to recapture the town had failed. The Serbian forces, now including 26 battalions and 7½ squadrons, were concentrated at Varna, during the night of August 15th, for a renewed attack upon Schabaz, by order of the Serbian H.Q. Staff, issued at 7 p.m. On the other hand, the 2nd Austro-Hungarian Army received definite orders to hold Schabaz. Hitherto, this Army had succeeded in holding up three Serbian divisions on the northern front. During the night of the 15th, Landsturm units were ferried to Schabaz, to reinforce the bridgehead garrison.

The ferrying of the 29th Division began at dawn, on August 15th. Fresh units reached the south bank continuously. The launching of the bridge (14) also began very early, the General's order including the following words: "*The decision of to-day's action depends upon the Pioneers.*"

The bridge was completed by the 1st, 2nd, 3rd and 4th Companies of the 5th, and the 1st Company of the 9th Pioneer Battalion, between 7.30 a.m. and 2.30 p.m. (without previous preparation). The work was not interrupted by the enemy, and was excellently

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carried out by the Pioneers, whose only experience had been training in peacetime. The Schabaz bridge is the longest bridge constructed during the Great War, and, in respect of the use made of it, should constitute a record. The sketch gives detailed data. The bridge was launched with pontoons, from the left bank. Since it was necessary to construct approximately ten extra bays—beyond the original estimate—in order to complete the bridge, two companies voluntarily undertook this task. Owing to a storm, with a strong wind, which made the insertion of the last pontoons very difficult, the work of completion was much hampered. At 5 p.m. traffic across the bridge began, amidst a thunderstorm and the opening of an artillery duel; a squadron of the 2nd Landwehr-Uhlan Regt. crossed first, and, with a few unimportant pauses, traffic continued uninterruptedly—in both directions alternately—for over 200 hours. Four Pioneer Companies were required for service on the military bridge, and two companies on the steam ferry. Moreover, the Pioneers were also responsible for tactical protection in the immediate vicinity, and for technical protection on the water, as well as for cover for guns, and various duties at the bridgehead. On August 15th, a military bridge was also constructed at Jarak. By the evening of August 15th, there were in Schabaz 34½ battalions (7th and 29th Divisions), which were not, however, ready to go into action on that day; the Serbians, also, let this day pass without any important action. At 3 p.m. orders were issued by their H.Q. Staff, for the recapture of Schabaz on August 16th; the enemy at the bridgehead must, at least, be cut off. The night preceding the 16th was comparatively quiet.

Important engagements again took place on the 16th. Gen. von Hortstein decided to make an attack from Schabaz, with the forces now concentrated there, in order to pin down the enemy. Meanwhile, the Schumadia Division began an advance on the town, but turned westwards, under the impression that their left flank was threatened. Therefore, the main body of the Austro-Hungarian forces did not gain contact with this Division, on the S.E. of the town; the 29th Division alone was heavily engaged at Dobritsch, which led to their withdrawal to the concentration point, whither the other troops also retreated in the evening. Towards midnight, large sections of the train were forced back from Schabaz to the north bank. Traffic on the bridge was very heavy during the whole day, and also at night.

On August 17th, the Serbians opened another strong attack upon Schabaz, which developed intensively; whereas the bombardment of the military bridge by the batteries at Mischar had hitherto been ineffective, the Serbians succeeded—at 1 p.m.—in destroying part of the bridge by several direct hits. Fortunately, few casualties occurred, since it happened that the general direction of traffic had

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altered, therefore, one part of the bridge—which would otherwise have been crowded—was clear. The situation was nevertheless critical owing to the interruption of traffic, whilst a reverse at the bridgehead might now lead to a catastrophe. Whilst the action in Schabaz was at its height, ammunition wagons suddenly appeared at the southern end of the bridge, on an urgent demand for ammunition from the hard-pressed batteries. For some time it was impossible to send a supply of ammunition across the bridge, since the part which had been hit could only be repaired under cover of darkness. But there was no ammunition on the spot which could have been taken across immediately. The units which had been cut off on the north bank, consisted of part of the 4th Hussar Regt., belonging to the IV Corps, which were to cross the military bridge on August 18th, and come into action on the south bank. Owing to continuous artillery fire, these units were forced to deploy over the ground, whilst in Schabaz itself part of the train had been cut up by fire. In order to provide ammunition, certain Pioneer officers rode off in the direction of Klenak. The first one succeeded in finding an ammunition column, and led it to the bank. The 2nd Pioneer Company at once began to load the ammunition cases on to pontoons. Officers and men vied with each other in carrying the cases, which were taken across the Save, the surface of which was constantly tossed by the falling artillery shell. On reaching the south bank, the ammunition wagons and limbers were loaded, and driven off at a gallop separately to their respective battery positions. Other Pioneer Companies were soon assisting in the transportation of ammunition, and the crisis on the south bank was over. The Serbians observed the interruption of traffic on the bridge, and the transportations, and interpreted the latter as a retreat of the Austro-Hungarian forces. They therefore opened a renewed surprise attack, which they were soon forced to suspend, since it was shattered by the return fire of the defence, on whose side the monitors did excellent service. The Serbians retreated to the heights south of the town. Although their attack had failed, yet the bombardment of the bridge had delayed transport of the cavalry of the IV Corps for seven to eight hours; it was, therefore, impossible for them to carry out a reconnaissance on August 17th, the lack of which was felt during the action on the 18th. The commander of the IV Corps—Gen. Tersztyánszky (Cavalry)—now took over the command in Schabaz. When darkness fell, the four sections of the bridge which had been destroyed were repaired by a detachment composed of picked pioneers—an operation which, however, occupied some hours. The transport of the IV Corps—which also used the steam ferry—began after midnight on August 18th.

Upon the arrival of the IV Corps in Schabaz, the forces within the town now numbered 35 battalions, with 26 batteries—in addition

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to 10½ Landsturm, and composite battalions. These troops opened the attack at 8 a.m. on August 18th, and during the day forced back the Serbians across the Dumatsche. Owing to the great fatigue of the troops—the IV Corps having just completed very lengthy marches—and to a severe storm, which broke at 6.30 p.m., the exploitation of success was impossible. The bridge was once more under fire the whole day.

On August 19th, the attack was continued, and the Serbian troops were forced back still further—in fact, across the Dobrawa. At midday, however, the trains of the IV Corps and some artillery units, were sent to the north bank: firstly, because very large numbers of troops and trains could not be concentrated in Schabaz—which was subjected to continuous bombardment; and also because the IV Corps received orders—at about midnight—to evacuate Schabaz, in consideration of the retreat of the 5th Army, across the Drina. In the midst of this movement of troops, *a heavy ammunition wagon broke one of the trestles on the left side of the bridge.* The quick intervention of the bridging party prevented any long delay.

At 5 a.m., on August 20th, the crossing of the IV Corps to the north bank was, however, suddenly suspended, since attacks from Schabaz were about to reopen. But, at 9.30 a.m., the IV Corps definitely retreated, and used the bridge, and the steam ferry throughout the day. The Serbians observed the clouds of dust raised by the return march of the IV Corps, and concluded that they were due to the approach of fresh troops to Schabaz. They could not, therefore, decide upon a definite pursuit of the IV Corps. The troops, remaining in Schabaz, received—in the afternoon—definite orders to hold Schabaz. The intention appeared to be to retain Schabaz for some time, as a bridgehead; during these days, therefore, the reinforcement of the military bridge by a temporary one was considered.

The passage of the last of the IV Corps continued uninterruptedly for the whole day, the Corps being followed by the Letovski group; from the afternoon of August 21st, therefore, the 29th Division only—with 13 battalions—remained in the town. The bridge was now under fire daily, but it was the first time that an interval of several hours' duration in transport occurred, and, at length, the Pioneers found an opportunity of effecting urgent repairs in the bridge, *the structure of which had suffered severely from continuous use, day and night, since August 15th.* The maintenance of the bridge in a workable condition involved, moreover, heavy labour and great care. Although the river level fortunately varied but little during the days of the battle, yet it was frequently necessary to readjust the anchorlines, refasten the lashings, correct the direction at every opportunity, repair slight damages, manage restive horses, and, in particular, to avert traffic congestion due to bombardment. Traffic

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management across the bridge was entirely in the hands of Pioneer officers. *The repeated opening of the cutbays for the monitors* also involved much work, since these vessels were sometimes in action below the bridge, and then again returned upstream. The bridge was the constant object of anxiety to all commanders, since the fate of all troops in Schabaz depended upon it. The certainty of uninterrupted traffic in both directions was the necessary hypothesis for all operations on the south bank. A serious interruption on the bridge might, at any time, lead to a catastrophe. This fact also explains the repeated Serbian attacks upon the bridgehead, against which—on the afternoon of August 21st—34 Serbian battalions and 6 squadrons once again attempted an attack. The position was, however, valiantly defended by the 29th Division, under Maj.-Gen. Zanantoni, and the enemy was even forced to withdraw to Varna. The 29th Division which, on the same day, also came into action in support of the sappers engaged in the construction of fortifications (seven technical companies being at the bridgehead), withdrew in the evening to the concentration point and was undisturbed at night. At Schabaz, it often happened that, after an engagement, the enemy forces separated. This may be explained by the assumption that the Austro-Hungarian troops did not always realize the retreat of the enemy, *since it was extremely difficult to effect a reconnaissance over country which could not be surveyed.*

On August 22nd, the 29th Division again occupied the inshore bridgehead, and on this occasion, a serious engagement took place, with the enemy, who was once more advancing upon Schabaz. Towards 4 p.m., fighting increased in intensity, yet the Serbians were again repulsed (rain fell on the 22nd). The situation was, however, more unfavourable to the 29th Division, since the Serbians had now surrounded Schabaz on all sides, and their forces were steadily increasing in number. Orders were, therefore, issued for all eventualities, with regard to a withdrawal to the north bank, which would, in any case, become necessary. The most vulnerable point was now the bridge, which was daily subject to bombardment and, on account of its length, its dismantling would take some time. In case of a reverse, very little time would probably be available. Therefore, orders were issued that, should a serious reverse occur, should the enemy make an attack, the bridge should be partly sunk, and partly destroyed by our own fire. The necessary preparations for this purpose were made, but the Pioneers were quite determined not to leave their bridge, any more than a gunner would abandon his gun in action. The 5th Pioneer Battalion remained at the bridge, and the other Pioneers—including the 15th Battalion recently arrived—with the steam ferry, and the various means of transport. Whilst these preparations were in progress, came the news that the IV Corps—which had already begun the march for entrainment

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to the Russian front—had been engaged on the south bank and, at 10 p.m., transport began by bridge and steam ferry, and the Corps moved for the third time to the opposite bank. The result of the engagement of the Corps was to repel the enemy—who were preparing for a decisive attack upon Schabaz—so that the latter could more easily be evacuated, according to plan as decided by the H.Q. Staff of the Austro-Hungarian forces in the Balkans.

On August 23rd, the lengthy columns of the IV Corps crossed the bridge, under heavy fire. At 2 p.m., the IV Corps and the 29th Division opened the attack, which forestalled the intended Serbian thrust against the military bridge which, by cutting off the garrison of the bridge, was to precipitate a catastrophe. The Serbian scheme was soon frustrated, and the advance checked. This result induced Gen. von Tersztyánszky, Cavalry Commander, at 7 p.m. to order the evacuation of Schabaz, by all troops, and the movement began immediately, with the retirement of the trains. *In addition to the military bridge, the steam ferry and a pontoon group, much reduced by fire*, were in action. For the protection of the direct crossing-point, the Pioneers dispatched their own signal patrols to the flanks of the bridgehead. The night was quieter, since the evacuation had completely escaped the observation of the Serbians, who were occupied in bringing fresh guns into position, for the continuation of their attack on August 24th.

The 29th Division was to hold the bridgehead until the IV Corps had left the south bank, and was then to cross the bridge, with the exception of a rear-guard battalion. No new orders were issued in reference to the bridge; it was, of course, the duty of the Pioneers to bring over the last of their comrades from the south bank, and, as far as possible, to save Pioneer equipment. At daybreak, artillery fire opened on the bridge, with greater intensity than before. A direct hit upon the close columns would inevitably have been disastrous. In order to facilitate the salvage of the bridge, the Pioneers began—even during transit—to remove the lashings, and take out some of its components. Behind the last wagon, the shore bay was taken up, shortly before 9 a.m., and the left portion of the bridge dismantled into whole and half sections, as used for exercises. All lower anchor ropes were cut through, since it was impossible to consider the raising of an anchor absolutely choked with mud. The remaining right portion—more than half the bridge—was so much damaged, that independent Pioneer groups embarked in pontoons, and released entire sections (three pontoons with two bays). Finally, the 3rd Company fetched pontoons numbers 95–97, and the 2nd Company brought up the remaining part of the bridge, on which many stragglers were transported. When, shortly afterwards, more stragglers appeared on the bank, the 2nd Company took two more pontoons to the Serbian bank, and brought the men into safety.

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The bridge was saved, and there remained on the Serbian bank nothing but pontoons riddled with shot, and a few stakes driven into the ground. All bridging material was left temporarily on the left bank, since Serbian artillery fire made it impossible to continue work there.

At an early hour, the Serbians once more advanced against the bridgehead, and at 9 a.m. their patrols reached the main square of the town—just when the bridge was dismantled. At 10.15 a.m., cavalry appeared in Schabaz, and at noon, the first body of infantry appeared on the bank. A violent artillery duel went on all through the day. After the nights of the 25th and 26th of August, the Pioneers were busily occupied in getting bridging material out of the water, loading and transporting it, and were meanwhile constantly harassed by artillery fire. This brought the battle of Schabaz to an end.

During this battle, the bridge was utilized by a total of 360,000 men, 2,500 cavalry, 260 guns, 20,000 vehicles and 100 motor vehicles. It was almost continuously under artillery fire, which, however, only at one place developed as effective demolition fire. The Serbians did not fire shrapnel upon the bridge, although it would have been very effective against troops who were crossing. Three serious accidents only occurred during transport across the bridge: the destruction of one trestle by an ammunition wagon; injury to one man, who was caught between a trestle of the bridge and a wagon; and the fall of a horse from the bridge into a pontoon. Losses of bridging material—due to enemy action—amounted to about one bridging column and a half, out of the 18 in use. To this must be added the 45 anchors, which could not be raised. In comparison with later river crossings during the Great War, these losses, and even the serious casualties amongst the Pioneers, must be considered light, as compared with, *e.g.*, 50 to 70 per cent. in the battle on the Piave, in June, 1918. Modern war equipment was still very deficient at Schabaz; there were no motor-boats, no river-cables, gas, aeroplanes, or balloons, and also no wireless and, needless to say, no tanks. Means of communication between the two banks was also very primitive; electric wire across the anchored pontoons, and also across the military bridge, which was, of course, interrupted at every opening of the cut-bay, visual signalling stations, and rowing-boats. At that period, fighting methods were still comparatively simple. The troops were, however, under a terrible strain, owing to the continuous calls upon them for 13 days—15 in the case of the Pioneers—without any actual interval of rest; the contradictions in the issue of orders, in consequence of the changing situation of the 2nd Army, and, in particular, of the IV Corps; there were many forced marches, and difficult fighting in a part of Serbia, where there was but little open country; moreover the Serbians had the advantage of fighting

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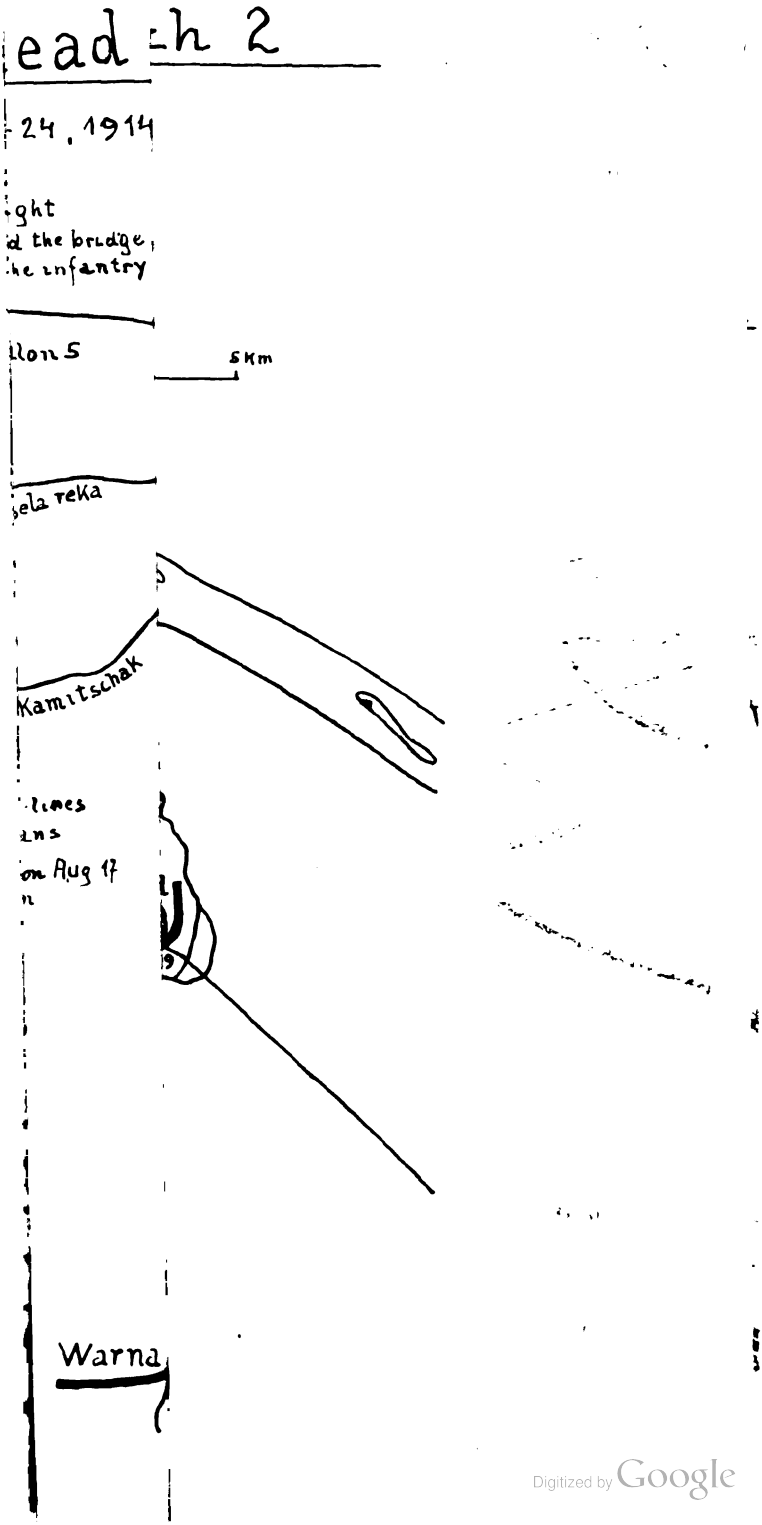

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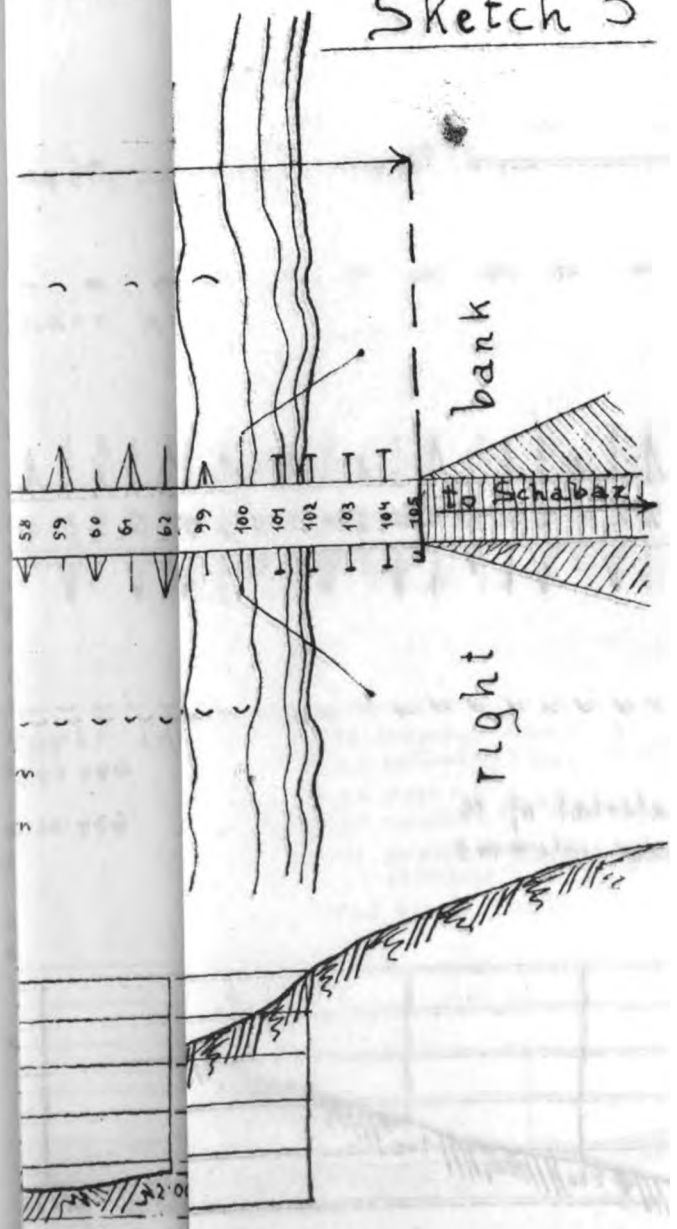
Sketch 3



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in their own country which they knew, whereas our forces were in enemy country.

In conclusion, we may ask to what extent the duties required were fulfilled on either side.

The mission of the Austro-Hungarian troops at Schabaz was to engage as large a force as possible of the enemy army, in order to enable the 5th Army to advance across the Drina, and return by the same route. The only method by which this could be effected was the maintenance of a sustained attack. In spite of temporary superiority of numbers (during the presence of the IV Corps), it was impossible to force a decision upon the Serbian troops, since the IV Corps and at first also the 29th Division were under orders at any moment to entrain for the Russian front, and these forces, therefore, could not be effectively employed. In any case, the evacuation of Schabaz without heavy casualties was a fine achievement—as was also the salvage of the great military bridge under critical conditions. It is scarcely possible to find in the history of war a similar example of a successful retreat, under enemy fire, across a great river.

The Serbians certainly have to their credit the final reoccupation of Schabaz. During the whole period of the battle, they did not, however, succeed in accomplishing what was several times within their power, *i.e.*, annihilating the enemy after landing, or inflicting upon him serious losses on the river. They did not take full advantage of the great opportunities of river defence. (Compare Saschinizi, 1914, and Rjahowo, 1916!) Probably, however, they had an effective protective screen against the further advance of the enemy. They possessed the advantage of greater military experience, and unity of command, since they were not obliged to conduct operations simultaneously on two fronts.

In the battle of Schabaz, the opposing forces of Austro-Hungary and Serbia were well matched and showed marching power and courage in action.

In conclusion, we may say that both sides did their utmost under exacting conditions, but neither succeeded in gaining a decisive advantage.

[NOTE :—*The sketches with wording and figures, are reproduced as received from the author of the article.*]

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SUGGESTIONS ON PREPARATION FOR PROMOTION EXAMINATION—SUBJECT (f).

By LIEUT. F. C. C. BRADSHAW, R.E.

INTRODUCTION.

THE object in producing these notes is two-fold. Firstly, officers, from time to time, have asked the writer what work he did in preparation for Subject (f), and he hopes (in spite of an excellent pamphlet on the subject, published in January, 1929, by the Field Works and Bridging School, S.M.E., Chatham) that a few ideas, stated from the point of view of a recent candidate as opposed to those of the " official " examiners, may prove of some help.

Secondly, there appears to exist the idea among some officers that preparation for this examination is a well-nigh impossible task, and moreover is unlikely to be of any practical value on the fateful day itself.

Their point of view seems to be this. Whereas preparation for (a) and (b) is fairly straightforward, as the syllabus is clearly defined, and there are plenty of past papers and many good text-books to help one, (f) is a very different proposition. Here the syllabus is so wide, that whatever problems may be studied beforehand, the project set is more than likely to be one not touched upon in such preliminary preparation. Again, it is argued, " why bother to do a number of practice schemes, when by taking the examination, one may be lucky and pass first time, thus avoiding any preparation? Or, in the event of failure, why not treat it as a practice scheme, benefit by the examiner's criticism, and try one's luck again in three months' time? "

The writer believes that it is possible to do sound constructive preparation and puts forward these views in opposition to those stated above.

Since (f) is not so easy to work for as (a) or (b), or, in other words, since (f) is generally considered a more difficult examination, it requires for that very reason all the more preparation.

Although the problems that could be set within the syllabus as laid down in *K.R.* are legion, one can safely remember that one's examiners were young officers once themselves, and are unlikely to set abnormally difficult projects. This means that the likely projects can be narrowed down to some half-dozen main types. Also,

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although it is quite impossible to anticipate what is going to be asked, preparation which enables you to solve one field engineering problem will assist you in solving any other field engineering problem. The preparation required is not so much the acquisition of a number of particular facts, as to get one's mind accustomed to thinking in the right way, so as to be able to weigh up certain factors presented to one and come to a decision quickly and accurately.

The last argument of " chancing one's arm," and perhaps passing first time, appears at first sight to be attractive. The writer personally thinks that it takes either a more than usually gifted officer or a more than usually lucky one to do this, not because the average officer is incapable of doing the normal project, but because the time limitation will probably defeat him. In the event of failure the first time, reading of the criticism of the examination with no further preparation is unlikely to help the candidate very much in the next attempt three months later.

Finally, the matter might perhaps be looked at from a wider standpoint than that of merely passing an examination. An examination is set not so much to see if an officer can do the particular test, as to try and make him study a subject with which it is necessary for him to be familiar, but with which he may not in the ordinary course of his day's work come into contact. As we are all human, the incentive to do this work is provided by the setting of a test. If work is carried out in a logical manner, the preparation for (f) should achieve the required result of making a sapper officer know his job a little more thoroughly.

To sum up, the second reason for writing these notes, is to try and show that it is possible and advantageous to do some work for (f).

Main Object of Preparation.

The writer fully realizes that no two people start working for an examination in the same way, and he merely gives his own methods of tackling the problem, which he hopes combine the merits of cutting out unnecessary work and being fairly logical. Every prospective candidate must, of course, work out his own salvation.

The first thing to do is to discover what Subject (f) entails. *K.R. Appendix X* gives the syllabus, and should be carefully read. " Notes on Preparation for Promotion Examination (Subject (f))," should be obtained from F.W. and Bridging School, Chatham, and thoroughly studied. As far as possible, remarks made in this pamphlet will not be repeated in these notes, and it is hoped that both will be read in conjunction.

The chief difficulty in doing an (f) project is to know how much of the whole solution to the scheme is expected in Part I, what to include and what to exclude, remembering the restricted time avail-

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able. Part II consists of " tidying up " the ragged portions of Part I, and giving all necessary further information required for a comprehensive and satisfactory solution. This should relatively be fairly simple. It is, therefore, considered that the main object of preparation should be to enable the candidate to produce a good Part I.

This Part falls naturally into two portions, more or less distinct. The first portion should contain all information showing what work is to be done, labour, tools, materials and transport required in the initial stages, *i.e.*, until more work can be provided by further elaboration of the scheme in Part II. This should be in pretty fair detail. The second portion involves a *rough* estimate of labour, time, transport, required for completion of the work, and a list of further stores required in the near future. This can, of course, only be approximate. It should be realized, however, that this second portion is of great importance and should not be neglected. It is better to cut down time spent on the first portion, in order that obvious requirements may be known to higher authority to help in furthering the work. Part II will enable one to justify unexplained means adopted in Part I.

It seems desirable for the candidate to work out *for himself* a sequence of work to be followed out in Part I.

The following sequence would appear to meet the case :—

1st Portion.

(1) Reading of the scheme, and thoroughly " getting into the picture."

(2) Reconnaissance of site or sites, and decision as to what one is going to do.

(3) Preparation of a list of all the various items of work that will have to be done arranged in order of necessary performance.

(4) Preliminary estimate of how much of (3) can be carried out in the initial stages (say, for first 6–8 hours).

(5) Necessary calculations for design of work to be done in initial stages.

(6) Diagrams of essential construction in initial stage (based on (4) and (5)).

(7) List of tools and stores required in initial stages, very often helped by inspection of diagrams in (6).

(8) Weights of essential stores and tools obtained in (7), other than those on the site, or in tool-carts, etc.

(9) Estimate of transport required for essential stores, based on (8).

(10) Estimate of number of men required for initial work, including men for fetching and unloading stores. At this stage, modification may be necessary as to what work can actually

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be carried out in initial stage. Stores may not be able to arrive at site as quickly as originally thought, and other work not necessitating stores may have to be put in hand, or alternatively, in order to quicken up delivery of stores, original work contemplated may have to be cut out.

(11) Final estimate of preliminary work to be done in form of work table (or working party table, as may be required).

2nd Portion.

(12) Rough estimate of labour and time required to complete the work. Allowance must be made for collection of stores and unforeseen contingencies.

(13) Rough estimate of transport required to complete the work.

(14) List of further stores required as far as time permits.

(The above three headings are dependent one upon the others.)

(15) Rendering of above in a neat, clear and concise report. Much of the report can be written out fair in the first place, but certain portions will require re-writing and others will not be included in report shown up at all.

Steps in Preparation.

It is assumed that the main object of preparation is to enable oneself to carry out the sequence of work in Part I as detailed above for any given scheme.

First Step—Preliminary Reading.

All necessary books, such as *M.E.* volumes, *Manual of Field Works*, *F.S.P.B.*, *War Establishments*, recent F.W. and Bridging School publications, and all recent amendments, etc., should be procured. These books should be carefully read, all important facts and suggestions can be underlined, and an index for quick reference in the cover of the book may prove useful. The object of this preliminary reading is to enable one to know what information is in the books, and to be able to turn up what is required quickly.

Second Step—Analysis of some Types of Likely Project.

Likely subjects are heavy bridging, involving a junction of spans, pile bridge, pontoon bridge, suspension bridge, landing pier, entraining and detraining troops, water supply, demolitions, field fortification.

To "analyse" a problem in each of these mentioned would take considerable time, and it is suggested that attention be confined to four or five. Others can be worked in as modifications, *e.g.*, box girder bridge can first be taken, and modifications necessary if a piled trestle bridge were used in place of it can be thought out, and

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so on. Consideration should be given to all main types of projects, but detailed analyses can probably be restricted to those types about which the candidate is least knowledgable. It should be realized, however, that each successive analysis becomes easier and takes less time. It is now proposed to take a simple example and show what is meant by "analysis."

Problem.—A heavy bridge to take loads class B is to be constructed on the alignment of a demolished bridge. Gap is 100 feet. Labour available is 2 sections of a field company, at present 2 miles from site. Infantry working parties can also be obtained for work, commencing at 1000 hours to-day. One 80-ft. 4-girder box girder bridge is available, also 30 ft. x 15 in. x 6 in. R.S.J.s, in store 5 miles distant from site at X. Three 3-ton lorries at X are available. This information is given out at 0800 hours to section officer of field company, who has to do the work. Required usual solution as laid down in *K.R.* App. X.

(*Note.*—It may be found in setting oneself a problem, that it turns out to be rather impracticable by reason of insufficient or bad data, but this will generally become self-evident as the scheme is worked out, and necessary alterations can be made. Setting oneself schemes in itself helps to make one appreciate the various factors affecting their solution. The above problem has not sufficient data for a real project, but should suffice for the work in hand.)

It is suggested that this problem be considered under each of the items in the sequence of work given on page 92. Looking at these, (1) and (2) do not require much consideration in an indoor scheme. It is obvious that the bridge will be a junction of two spans—80-ft. 4-girder box girder bridge and a 30-ft. built up R.S.J. bridge.

The prospective candidate must consider *for himself* what are the various items of work to be carried out as per item (3) of sequence.

The following is given as a suggestion :—

x (1) Reconnaissance of site.
x (2) Setting out.
x (3) Removing debris.
x (4) Loading and unloading stores and tools (carried out at intervals as other work proceeds).
x (5) Excavation for bank seats of bridge and mudsills of trestle pier.
x (6) Construction and placing of above.
(7) Construction of trestles.
(8) Erection of trestle pier.
(9) Preparation and erection of R.S.J. span.
(10) Erection of launching gear for box girders.
(11) Erecting girders.

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(12) Launching girders.
(13) Laying decking and completing bridge.
(14) Dismantling launching gear, clearing up, notice boards, etc.
x(15) Work on approaches (carried on as other work proceeds).

The next item is the preliminary estimate of work which can be carried out in initial stages, say, the first six hours. The accuracy of this estimate depends on the officer's previous experience and imagination. The headings marked " x " in the previous paragraph are suggested.

Next come the necessary calculations. Considering work to be carried out in initial stages, the designs of bank seats and mudsills are required. To calculate bank seats, weight of both bridges is required. That of box girder bridge can be found from tables in *M.E.*, Vol. III, that of R.S.J. bridge cannot be found until bridge or main portion of it is designed. The mudsills cannot be calculated until the rest of the trestle pier has been designed. Apparently, then, most of the total calculations are required in Part I.

At this stage, it is suggested that the full calculations for R.S.J. bridge and trestle pier be worked out for several reasons. It will ensure that the candidate can do the required calculations readily; the length of time required for such calculations will be discovered; it will help candidate to find out what calculations are required, *e.g.*, when shear need or need not be considered, and it will give him a notion of size and quantities, *e.g.*, likely sizes of timber required for heavy trestles and so on.

As a result, it will probably be realized that it is quite impossible to carry out all the calculations in time allowed for Part I. The problem appears to be in the nature of a vicious circle, thus: " I have not got time to calculate much, therefore the work to be done must be in the nature of marking out, excavation, fetching stores, so my calculations can wait. But how can the men collect any stores, or how can I discover what transport is needed, or even how many men to cope with their collection, until I have worked out the designs, thus arriving at what stores are wanted. Even to work out designs of the work that I want to start on first seems to necessitate my doing nearly the full calculations."

There is, of course, a compromise, and the discovery of how to compromise intelligently is the whole essence of preparation. *Exactly how much calculation is required must be decided upon by the candidate himself.* The full calculations have now been worked out. The candidate can form an idea of how quickly he can calculate, bearing in mind that practice increases speed, and a little consideration should enable him to discover what is essential. There is no golden rule or simple formula, but at all events this preliminary thought on the matter can be done far better now than under the

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stress of examination conditions. The writer puts forward the following as a solution regarding calculations required in this case :—

(1) Calculation for R.S.J. bridge (not a very large order).
(2) Calculation for bank seats (or, if preferred, suitable design can probably be found from intelligent consideration of plates in *M.E.*, Vol. III).
(3) Calculate height of trestle legs. Approximate design of trestle pier, assuming normal type of trestle for heavy bridge, 12 in. x 12 in. timber, 3 legs and 2 rakers, can then be made. (Full calculation can be done later in Part II.)

The next item is "diagrams of essential construction." The following are suggested :—

(1) Site plan.
(2) Elevation and plan of proposed reconstruction in position.
(3) Sectional elevation of R.S.J. bridge (to simplify the estimate of stores required for it).
(4) Sectional elevation of trestle pier. This can be copied from similar design in *M.E.*, Vol. III (also to simplify the estimate of stores).

As regards stores required in initial stages, a list of stores required for bank seat, trestle pier, R.S.J. bridge, can be made out in tabular form quite easily from previous work, and weight of such stores ascertained roughly in lorry loads can be given in a column of the table.

This completes items (7), (8) and (9) of sequence of work. Item (10), which is, of course, the most difficult one now presents itself. This can be done by deciding or calculating :—

(1) Number of men and time required to complete initial work requiring no tools or stores other than those carried in tool carts, *i.e.*, reconnaissance, setting out, removing debris, excavation for bank seats and mudsills.
(2) Strength of infantry parties required for loading and unloading three lorries in an economical manner.
(3) Length of time a lorry will take to be loaded, travel to site, be unloaded and return to store dump.
(4) From (3). Total number of lorry loads of stores that can be carried during six hours, and thence what stores can be got to site in that time.
(5) Time taken before first consignment of stores arrive at site, and thus when field sections can commence work on bank seats and mudsills, and how much of this work can be done in first six hours.

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In this way, the work that can be done in first six hours can be reasonably ascertained. A certain amount of readjustment may be necessary, but it must be borne in mind that too accurate forecasting is not essential as all kinds of unforeseen events may occur. What is required is merely to show a reasonable forethought on the part of the candidate to ensure that men are well employed on useful work as soon as possible.

Item (11) of the sequence then follows naturally from previous work.

The second portion of Part I now remains.

The work left to be done is naturally all that could not be carried out in the first six hours.

Further stores required are all those already worked out in first portion of project not yet collected, if any, and these can be supplemented by noting down as many obvious requirements as possible, *e.g.*, box girder sections and launching gear, etc. The stores can be roughly sorted into lorry loads to gain an idea of likely transport required. Time and labour for remaining work can be roughly estimated in man-hours, and a percentage added to allow for wastage, as labour cannot always be economically employed. Consideration must also be given for unforeseen contingencies and night-working. A definite time and date for completion of work is required, so consideration of number of shifts is generally necessary.

To complete work required for Part I, it is a useful exercise to write out a specimen report in pencil in A.B. 153. Special consideration should be given to constructing suitable tables for work table, stores lists, transport indents, etc., in A.B. 153, as space is restricted. All information, whenever reasonably possible, should be given in tabular form.

As regards preparation for Part II of the scheme, it is probably enough to consider what remains to be done, and write down in order how it would be carried out. It is a matter of personal opinion as to whether the whole of Part II should be carried out in detail. The writer considers that probably certain portions about which the candidate is uncertain would suffice.

Having carried out this "analysis," the candidate should then think out the effect of alterations in data, *i.e.*, how problem might be affected for a skew span, unusually restricted site, water gap, less or more labour, and so on. The more angles the problem is studied from, the better, and any attempt to form too stereotyped a notion of any likely type of project must be rigorously checked.

Third Step—Practice Schemes.

When the candidate has done a few analyses, then a senior officer should be asked to set a few practice schemes. Many officers may ask why practice schemes should not be entered upon at once, and

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let all this " analysis " be done on these schemes. The answer to this is that the value of practice schemes as a *test* is thereby wasted, as an analysis cannot be done under a time limit. For this reason, the writer is of the opinion that analysis and all preliminary work should be done by the candidate by himself. Let him enlist the aid of a senior officer when he has found some difficulties to be solved. A senior officer may, and probably will, give excellent advice on how to solve a problem or avoid difficulties, but this is of no value until one has discovered the problem and difficulties for oneself which become therefore realities to one.

The scheme should be done, as far as possible, under examination conditions, and certainly within a time limit. Criticism and " counter-criticism " of the scheme should be of the utmost value, and everything learnt should be rationalized with previous preparation.

THE EXAMINATION ITSELF.

The only points the writer wishes to accentuate here are :—

(1) Careful reading of the scheme on presentation.
(2) A second reading of scheme on arrival at the site before commencing work.
(3) " Time spent in *sensible* reconnaissance " will not be wasted. Writing should not be commenced in a hurry through fear of wasting time. Also, the reconnaissance should be thorough. The site cannot be revisited.
(4) It is worth while remembering that a good Part I probably means success, and a poor Part I is difficult to bolster up in Part II.
(5) Reports should be briefly indexed and paragraphed. As much information as possible should be tabulated or indicated on sketches, and, above all, the report should be written so that it is quite clear what is wanted to anyone else reading it. How often one thinks what a fool a man is who writes and asks for something without giving enough particulars, and how often one does it oneself !
(6) Careful re-reading of Part I, when handed back before starting work on Part II.
(7) Time should not be wasted in vain repetition in ink in Part II of what has already been stated in pencil in Part I.
(8) The candidate should always put himself in the position of the man who has to do the job, and so ensure that all information necessary for its execution will be included.

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AIRSHIPS AND THE EMPIRE.

By Bt. Major G. MacLeod Ross, M.C., M.Eng., A.M.Inst.C.E., R.E.

The dramatic circumstances so intimately connected with all trans-Atlantic flights by aeroplane have built up a popular impression that the aeroplane in its ultimate stage of development will be the vehicle whereby long-distance, non-stop flight may be commercially achieved, and as an offset to this belief it is not inappropriate to recall that Lindbergh was but the hundredth man to cross the Atlantic by air.

For a variety of reasons the development of the aeroplane has been kept in the forefront of public vision, and the means whereby the mental attitude previously mentioned has been built up are not hard to discover. In the first place, it has been estimated* that one hundred times more money has been expended on the development of the aeroplane than upon the airship. This is largely due to the fact that useful experimenting can be carried out on the aeroplane on a comparatively small scale and at a low outlay per unit, subsequent operation, maintenance and replacement being correspondingly cheap. Aeroplane development has also benefited by the attention it received during the War, whilst interest has been quickened of later years by peacetime raids on London, and by some spectacular writing, at a time when economy was the watchword, purporting to expose the inherent unsoundness of the airship.

Airship development, on the other hand, has suffered and will continue to suffer, from that weighty handicap, that the smallest useful experiment entails expenditure on construction on a scale not only vastly greater than that of the aeroplane but beyond the means of the private firm, and this scale of expenditure is continued when operation and maintenance costs are considered. This factor has also helped to present an unreal magnitude to the constructional failures which airship development has suffered in the past. It is for this reason that the airship has attracted to itself in this country an additional handicap, in the form of development solely by the State, a handicap from which the aeroplane has kept comparatively clear. In consequence, progressive action on airship experiment has often become a political issue, and progress has been staccato, whilst the high degree of vulnerability of the airship precluded it from serious consideration during the War period from which so many mechanical and electrical devices benefited.

* Adm. Moffatt, Chief U.S. Bureau of Aeronautics, Navy Dept.

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As a preliminary, then, to a consideration of the characteristics of the airship, it will be useful to underline some limitations of the aeroplane in the sphere of long-range non-stop flight.

LIMITATIONS OF THE AEROPLANE.

The aeroplane is sustained in flight by dynamic forces, and its gross lift is controlled by its aerofoil surface and its speed, and in consequence it follows that the paying load per horse-power, which is the only satisfactory commercial criterion of any form of transportation, remains practically constant whatever its size up to a point where, in the case of very large aeroplanes, a decrease in paying load per horse-power occurs.

Practically speaking, it is no exaggeration to say that trans-Atlantic non-stop aeroplane flights have been purely examples of human endurance. Commercially, they have been stunts, and it can be shown that, with the materials known at present, the commercially paying range of non-stop flight for the aeroplane is around 500 miles, and that, judged by this standard, the size to which an aeroplane may be usefully developed is definitely limited. Capt. Richardson, of the U.S. Navy,* has calculated that the commercial efficiency of an aeroplane commences to diminish when its size exceeds 22·3 tons, a size which is four times that of the largest plane which has yet crossed the Atlantic. Using well-tried standards of performance, it is possible to show that an aeroplane of this size would have a maximum range of 3,460 miles, which would enable it to fly non-stop from New York to London, but it would have no capacity available for a commercial load as all the spare lift would be utilized by fuel. Added to this, there would be no safety factor in the way of power reserve such as is considered essential in all other forms of transport, and which in the case of the largest trans-Atlantic liners, is present, over and above normal operating requirements, to the extent of 35% of the total installed power, and in the case of an express locomotive to the extent of 62%, whilst a passenger aeroplane service works with a 50% reserve of power. The deduction to be made from all this is that the aeroplane, large or small, has a comparatively short commercially effective non-stop range, and it is unsuitable physically for flights over water.

In fairness to the aeroplane, it should be pointed out that recent research into the question of refuelling whilst in flight, and a recent survey of the ocean bottom between New York and Bermuda, where an area was discovered, four miles square, and raised 3,600 feet above the surrounding ocean bed, such as would be suitable for the anchorage of a sea aerodrome (Fig. 1), may go some way to minimize the present limitations.

* Figures in this and the two following sections are based on a lecture by C. B. Fritsche, Esq., Vice-President, Aircraft Development Corporation, June, 1928.

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Notice should also be taken of the Ciervo Auto-gyro (Fig. 2), and the attempt to combine the wings of the plane with lift derived from the gas in an envelope, both of which are attempts to increase the commercial efficiency of the plane over long distances.

Finally,* a new gyroscopic compass, an extremely sensitive altimeter, an " artificial horizon," and a short range (15 to 20 miles) radio beacon, provided by the Guggenheim Fund for the Promotion of Aeronautics, afford hopes that the dangers of aeroplane flights in fog and by night may be materially lessened.

The Flying-Boat.

It is when the flying-boat of the Short " Calcutta " (Figs. 3 and 4), or Dornier type, is considered that the limitations of commercial efficiency due to size begin to disappear. This superior characteristic of the flying-boat is held to be due to the substitution of a hull for the landing gear required on an aeroplane, which in the case of an aeroplane, equivalent to the 40-ton flying-boat, Dornier DoX (Fig. 5), would mean wheels probably six feet in diameter.

It is mainly on account of the weighty landing gear necessary that the landing speed of the aeroplane has to be kept to lower limits than are practicable in the case of the flying-boat, and this reacts to necessitate a lower flying speed in the case of the aeroplane.

The accompanying curve (Fig. 6) plots the gross weight of five increasingly large Dornier flying-boats against their useful load (to be distinguished against paying load) per h.p., from which it can be seen how a useful load of 2·19 lb./h.p. for a half-ton boat, rises to 9·47 lb./h.p. for a 50-ton boat. By way of comparison, the corresponding figures for the new Fokker F.32 aeroplane, weighing 11 tons, are also shown. This is the largest aeroplane built in the United States up to the end of September, 1929, though it has since been destroyed by fire.

It is found in the case of the flying-boat that the weight of the hull per cubic foot displaced drops as the size increases. The weight of the wings per square foot increases with the size, but this is offset by the gross lift per pound of structure increasing with size. The weight of the fuel and oil tanks also decreases with increase in size per gallon carried.

However, even with the 40-ton Dornier boat, a maximum range of only 2,635 miles non-stop is possible, and such a boat is consequently useless on the northern trans-Atlantic service, though it will probably operate on the New York–Bermuda–Azores route, the longest leg of which is 2,000 miles. But even here its calculated paying load would only amount to 1·23 lb. per h.p., which is poor compared with the 5 lb. per h.p. attained by aeroplane mail services over the

* See *The Times*, September 26th, 1929.

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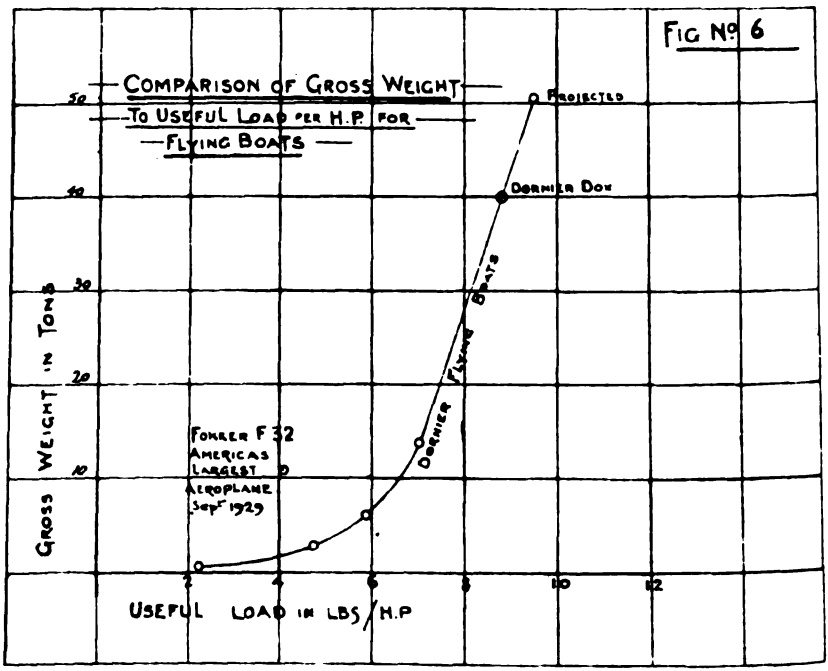
500-mile hops which constitute their commercially effective non-stop range.

The position of the flying-boat is that, provided suitable refuelling points are available, the large flying-boat has possibilities for longer range commercial over-water flights than the aeroplane. It will, however, be shown later that it can never compete successfully with the airship for economy, comfort or safety.



THE CHARACTERISTICS OF THE AIRSHIP.

The airship is sustained in flight by static forces, and its gross lift is directly dependent upon its volume and independent of its power plant, from which it is clear that increased lift is more easily obtainable in the case of the airship than in the aeroplane or flying-boat, since it is simpler to increase volume than to increase area.

In practice, the useful load carried by an airship increases very rapidly with the volume. Reference to Fig. 7 shows the gross weight plotted against the useful load in lbs. per h.p. for the airships at present in existence. The enhanced scale of this graph compared with that for the flying boat (Fig. 6) demonstrates the marked superiority of the commercial performance of the airship over its nearest competitor—the flying-boat.

The following comparative table of two aircraft of the same horsepower but showing the airship capable of transporting 13 times more

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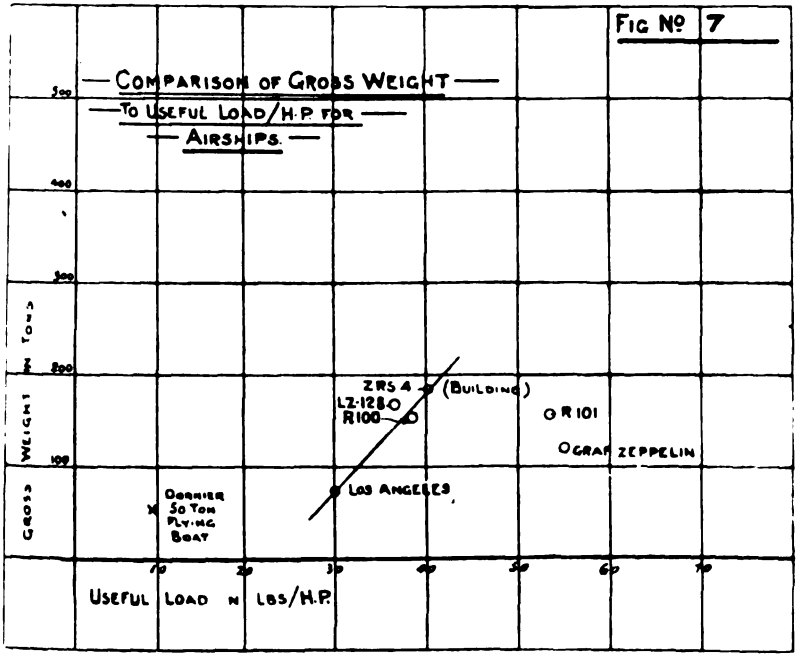
paying load than the flying-boat, makes clear the former's unchallenged position as *the* long-range, non-stop aircraft.

The flying-boat, it will be noted, has to make three refuelling stops, and flies *via* the Bermuda–Azores route to London. The airship flies with the crow from New York to London.



PERFORMANCE OF AIRSHIP COMPARED TO FLYING-BOAT, NEW YORK TO LONDON.

	Airship.	*Flying-Boat.*
Units of Comparison.		
Gross weight, tons	250* ..	50
Useful load, tons	140 ..	25
Paying load, tons	65 ..	5
Horse-power	6,000 ..	6,000
Paying load per h.p./lb.	21·67 ..	1·67
Route Comparison.		
Distance, miles	3,200 ..	4,400
Time required (still air) hours ..	43 ..	43
Landing, including intermediate stops	1 ..	3

* An airship of 250 tons has yet to be built but it is well within the realms of practicability.

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It can, therefore, be definitely asserted that the large rigid airship is the vessel of the future for long-distance, heavy cargo transport over sea or land.

Before passing to a discussion of the technical and operational aspects of the airship, it may be interesting to note the gross weight of vehicle required per passenger in various forms of transport:— In a 200-passenger airship, 2,500 lb. per passenger would be required. In the steamship *Leviathan*, 26,000 lb. per passenger, and in the railway express train, the *20th Century Limited*, 9,000 lb. are required. The repercussion of this fact on questions of economy in material, capital, maintenance and replacement is very considerable.

SOME TECHNICAL CONSIDERATIONS.

Of the 149 rigid airships built by the nations of the world to date, 133 have been built by Germany, and 14 by Great Britain.

Of the grand total, the R.38, the *Shenandoah* certainly, and the *Dixmude* probably, failed as a result of structural weakness, and it has been suggested* that, in spite of this long experience in rigid airship construction, Count Zeppelin probably lacked a full theoretical knowledge of the problem with which he wrestled, and it has remained for the whole theory of airship construction and operation to be investigated by British brains on a broad and scientific basis during the years 1921 to 1928.

The R.100 and the R.101 (Fig. 8) are the material outcome of these investigations and research.

A rough specification of the R.101 is as under:—

Capacity	5 million cubic feet.
Length	732 feet.†
Diameter	130 feet.
Displacement	150 tons.†
Engine power	3,000 h.p.† 5 Beardmore "Tornado" Diesel Oil Engines.
Fuel oil carried	30 ton.
Maximum speed	80 m.p.h.‡
Range at cruising speed (71·5 m.p.h.)..	3,500 miles.‡
Carrying capacity	100 passengers and mails,‡ or a useful load of 30 tons.†
Ratio of length to girth ..	5½ to 1.†
Goldbeater skins in the 16 gasbags	1½ million.
Area of cotton in gasbags ..	10 acres.

* See "*Airship R.100*," published by the A.G.C.Ltd.

† All these figures will be altered as a result of an additional section now being added to the R.101.

‡ Subject to confirmation on tests.

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Area of outer covering ..	5 acres.
Propellers	16 feet diameter.
Push exerted by each propeller	1 ton.
Framework contains	27 miles of tube.
One quarter total weight is stainless steel.	
Height of each rudder	45 feet.
Total area of the 4 fins ..	9,000 square feet.

Comfort to a degree unknown in an aeroplane is provided in the shape of an electric kitchen, two- and four-berth cabins, a promenade large enough for a dance, proper washing and lavatory accommodation, whilst noise has been almost entirely eliminated. The upper deck has an area of no less than 5,500 square feet.

The salient point to remember in connection with the R.100 and R.101 airships (Figs. 9, 10, and 11) is that they are of the smallest size practicable, not only as a basis for future development, but as a test of the research already referred to. The R.100 is designed only for temperate climates, but she is calculated to excite commercial interest sufficiently to place the further development of the airship in commercial hands without any State intervention. Success on her tests, and those of the R.101, which is designed for Eastern routes, will alone achieve the realization of this last hope.

It is now proposed to consider some constructional details of airships in general, and of the new British ships in particular.

Frame.

The R.100 and R.101 have been designed to withstand an enforced rate of rise of 4,000 feet per minute, as compared with 1,000 feet per minute for the older British ships.

Mere wind velocity puts no force upon an airship in flight, danger arising chiefly from vertical currents of air. The *Shenandoah* hit a sudden vertical current of air having an upward velocity of 15 m.p.h. The R.100 would be safe in an upward current of 50 m.p.h., and is equal in strength against air disturbances to the standard of the present day passenger-carrying aeroplane.

The new ships have been designed to stand a breaking load of 30 tons in any direction at the bow, whereas R.33 broke away from her mooring under a lateral load of less than 4½ tons.

In general, it may be said that the ships R.100 and R.101 have been deliberately built too strong in order that they may be tried out in really bad weather.

Gas.

British airships use hydrogen as their "lifting" medium and since hydrogen, in combination with petrol vapour, produces an appreciable fire risk, the discovery of helium, an inert gas, was hailed

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as indispensable in the interests of safety. Helium is at present found only in the United States, and has not become universally available, although it is reported to have been found in Canada. The present cost of helium is 1¾d. per cubic foot, which is very high, but since its use may be extended, apart from airship requirements, to various medical and scientific uses, as, for example, in radio tubes, housings of high-speed gyros and in toy balloons, the cost may soon be down to a penny per cubic foot. The supply available in one field alone in the United States is estimated at 20 million cubic feet per annum for 50 years, without touching the State Helium Reserve in Utah.

Apart from the price, another disadvantage is that the range of a helium-filled ship is 30 to 40 per cent. less than that of a similar ship filled with hydrogen, since helium has not got the low specific gravity of hydrogen, and, therefore, before deciding whether this loss of performance is commensurable with the safety obtained, it is as well to investigate exactly the degree of risk constituted by the use, in combination, of hydrogen and petrol as is done in the R.100.

The danger arises from a combination of hydrogen and petrol vapour. Now the hydrogen which fills the several gasbags is in the upper portion of the ship, and is, of course, lighter than air and tends to rise on escaping. The petrol being in the bottom, the vapour can be satisfactorily prevented from accumulating by well-designed ventilating arrangements. With such precautions, it is doubtful whether the disadvantages of helium do not outweigh its advantages which will tend to diminish still more with the development and use of the heavy oil engine burning non-volatile fuel, such as has been provided in the R.101 and which is requisite for operation in the East.

Engines.

From a popular point of view, the main interest, as far as the engine is concerned, lies in the nature of the fuel burned. The disadvantages of petrol have been mentioned, but engines, such as the Beardmore " Tornado," used in the R.101 (Fig. 12), burning heavy fuel oil, secure both safety and increased economy. The risk of fire is minimized, a low priced fuel is employed, and consumption is reduced so that on a voyage to Egypt four tons saving in weight in bulk of fuel carried will be realized. A third alternative is the use of " Blau " gas, as employed in the *Graf Zeppelin*. This gas has an explosibility range one-sixth that of hydrogen, and a density approximating to that of air. Its use as a fuel, in conjunction with petrol, may result in an increased endurance of 40 per cent. Its use also means simplification of operation, since as the gas is burnt, the equilibrium of the ship is unaffected, and there is no need either to " valve " hydrogen or to resort to water-recovery.

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Airship Operation.

Numerous as are the difficulties to be overcome in the design of an airship, the operational obstacles connected with a vessel which would nearly fill Northumberland Avenue, and stands as high as the Nelson Column, are not to be overlooked. The airship requires certain terminal facilities, and of these, the mooring mast (Fig. 11), which has been evolved and has now been erected at Cardington, Ismailia, Karachi, Montreal and Durban, is the equivalent of the landing-stage so essential to the ocean-going liner. With the assistance of only 14 men an airship can be moored at such a mast in a wind of 30 m.p.h., and can ride out a storm of 60 m.p.h. The cost of these masts is £50,000 apiece. But with present standards of construction, shelter is on occasion required for an airship and a hangar must be provided in the same way that a liner requires the services of a dry dock. Although these hangars (Fig. 13) may cost £150,000 to £500,000, as the size of the craft increases, the terminal requirements are small compared with the requirements of ocean-going ships. Just as a steamship is often prevented from entering a dock by tide and wind, so an airship cannot enter a hangar in a wind exceeding 15 m.p.h., and must ride at her mast until the weather abates. Again, as a steamer requires the assistance of tugs and winches to dock her, so it at present takes 400 to 700 men to handle an airship into a hangar and the expense of keeping such a large gang available is a question which will doubtless soon be solved in a more economical manner. The Germans are experimenting with revolving hangars, which will rotate into a position in line with the direction of the wind, and are attempting to evolve a rail truck to which the ship may be attached and drawn down. But, up to date, the handling of a gigantic feather having a mass of 150 tons, but no weight, is most safely undertaken by man-power. Once the airship becomes commercially attractive, its size will increase by leaps and bounds and each ship constructed will require a new series of hangars along its route. The Americans talk of erecting artificial lakes of diameter the length of the hangar on which it will float, and they have also experimented successfully with mooring masts on sea-going aircraft carriers.

The satisfactory solution of the docking problem is essential for the commercial realization of the airship.

Meteorology and Wireless.

It has been said that with airships, navigation and meteorology are inseparable, and efficient operation is impossible without a first-rate weather service.

Attempts have been made to discredit airship evolution on the strength of the statement that an airship, owing to its low relative

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speed, would be unable to make headway against unfavourable winds and would be unable to avoid storm areas.

The chief dangers to be faced by an airship are vertical air currents and the necessity to valve hydrogen gas in a thunderstorm. Given an accurate weather chart, an airship can avoid both dangerous and unfavourable conditions with the speeds obtainable to-day, which are already twice that of the rate of travel of the average storm area. Dr. Eckener, on the completion of his world cruise, asked what changes he would wish in the *Graf Zeppelin*, decided first upon increased volume, thereby attaining greater efficiency and range, and next, for more speed, the greatest attribute for safety an airship can possess.

The dawn of the commercial airship lends added point to the Polar exploration now being carried on by Wilkins and Byrd, and their endeavours will do much to make the operation of airships safe.

The map (Fig. 14), showing the observation and broadcast stations which assisted the *Graf Zeppelin* on her recent 26,000-mile cruise, gives a good idea of how the world's weather service is progressing. But this meteorological service can only be made use of by reason of wireless intercommunication and the scale of the airship, compared with a plane, enables the former to instal much more effective apparatus. The wireless set on the R.101 can operate over a 2,000-mile range, which means that it can anticipate the weather conditions over an area of 12½ million square miles, equal to almost one-quarter of the land surface of the earth. We therefore have our operational safety chain dependent first, on meteorological observation, next on wireless, and finally, on the speed of the airship to utilize the information so afforded. At present, airship speeds range about 80 m.p.h. maximum, but these will improve rapidly as sizes increase and speeds of 100 m.p.h. are not far removed.

IMPERIAL AIRSHIP ROUTES.

It must be again reiterated that the R.100 and R.101 are experimental, and that on their satisfactory performances will primarily depend the establishment of commercially attractive Imperial airship routes.

The best conditions under which to operate the aeroplane commercially are those which provide a series of concentrations of population at 500-mile stages apart. Such conditions exist in the U.S.A., and are being exploited to great effect. The arrangement of the British Empire, however, is such that the average commercially useful stage is 1,000 to 1,500 miles, and whilst the aeroplane is vitally important for feeding to terminals, it is the airship which is peculiarly suited as the modern form of transport for the development of Imperial routes.

The long, non-stop range of the airship immediately places it

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ahead of the limited paying range of the aeroplane when we consider a flight to the East from England. The nearest British possession is Gibraltar, 1,000 miles distant. A stop here necessitates not only a long détour but as a first stage it is most uneconomic for an aeroplane, and so it may be said at once that an " All Red " route to the East by aeroplane is impossible.

With the airship, the first stage to the East will be to Ismailia in Egypt, which will be reached by R.101 in two days. The next stage will be to Karachi, India, in a total time of 4½ days ; continuing to Australia, it would appear that the best route would be *via* Singapore to North Australia, but it so happens that this would lead into a thunderstorm belt which is continuous to the North of Australia, whilst the heat experienced in this region is to be avoided, since the air is more unstable and the airship will deteriorate more rapidly.

It follows that an airship base in South Australia will be most satisfactory.

But there is another interesting fact to recall. Empire colonization was guided very largely by the routes taken by the sailing ships of old, which made use of the prevailing winds, and so in the new era of the airship, advantage will once again be taken of these winds, and we shall find that on the trip from Capetown to Perth (Australia), the " roaring forties " will be utilized, whilst in the reverse direction, the S.E. Trade winds will assist the airships on a more northerly course to Capetown.

So much for the effect of natural climatic conditions on the selection of airship routes.

There is another factor to be weighed. The class of load transported by airship is likely to be, first, even if not ultimately, of a first-class nature : passengers, mails, specie and valuable light freight generally.

The two great streams of first-class traffic in the world, flow from North America to North Europe, and from South America to South Europe respectively. Of these the former is the larger, whilst the latter could never be described as Imperial.

The former, which may be called the Canadian route, and which will also tap the United States, will require for commercial operation a larger type of airship than either the R.100 or R.101, owing to the prevailing weather conditions, but it should be noted as the Imperial route which offers the best chances for the early establishment of an unsubsidized service.

With the establishment of this route in operation, it will be possible to leave London on Saturday night, have a full day in New York on Tuesday, and be back in London on Thursday afternoon. Such a possibility means an immense saving of time, half that required by steam or motor-ship, and assuming fares to be equal, it has been estimated that such a service will attract some 20 per cent. of the

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normal first-class steamship passengers, and with such a volume the service will be commercially established.

Letters, cables, telephony, wireless, all assist in keeping people in touch, but none of these can equal personal contact in effectiveness. Consider then the possibilities offered by a form of transportation which, even at present speeds, can bring India within 4½ days, Australia within 11 days, Canada within 2 days, South Africa within 5 days, and New Zealand within 14 days, of London.

In the realm of Imperial relations, it will bring the Dominions to the Mother Country at a week's notice when far-reaching decisions affecting the Empire must be taken. Imperial conferences can be held every year, and the highest authorities can be heard personally, instead of by proxy. Better relations and speedier decisions will be the outcome:

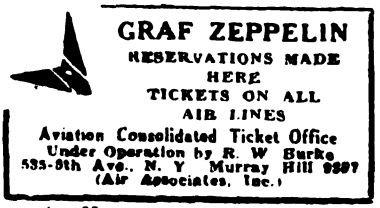
Commercially, the possibilities are obvious, whilst, in the domestic sphere, it may be noted that children will be able to spend their holidays with their parents serving abroad.

Finally, when it comes to the question of the ownership of these commercial airship lines, let us hope that the shipping companies of Great Britain will have profited by the experience of the railways in regard to motor transport, and of the cable companies in regard to wireless. For the preordained operating agents for Imperial airship routes are undoubtedly the shipping companies with their world-wide ground organization already established. If they grasp the gage, they will not be ruined like the railways by losing all their "first-class" traffic, but they will reap the benefits of a speedier vehicle, and be able to continue to operate their steamships at speeds and for loads which are commercially sound in the face of the new conditions imposed on world transport by the airship.

It is interesting to remark that Lloyd's Register of Shipping has now undertaken the specification and survey of privately-owned aircraft and the expression "A1 at Lloyd's" will, in future, apply to aircraft.

Finally, on October 14th, after the successful mooring of R.101 at her mast on the 12th, congratulatory telegrams were received from the Chairman of the Orient Steamship Line, amongst others.

Let us hope that these are straws in the wind, and that, as a result of their tests, the two "R" class airships will between them lay the foundations not only of the commercial development of the airship, but also of the commercial airship routes of the Empire.


GRAF ZEPPELIN
RESERVATIONS MADE HERE
TICKETS ON ALL AIR LINES
Aviation Consolidated Ticket Office
Under Operation by R. W Burke
535-5th Ave., N. Y Murray Hill 9897
(Air Associates, Inc.)

AN HISTORIC ADVERTISEMENT.

The first advertisement soliciting patronage for an airship to be published.
A cutting from the *New York Times* published before the *Graf Zeppelin* sailed on her world flight.

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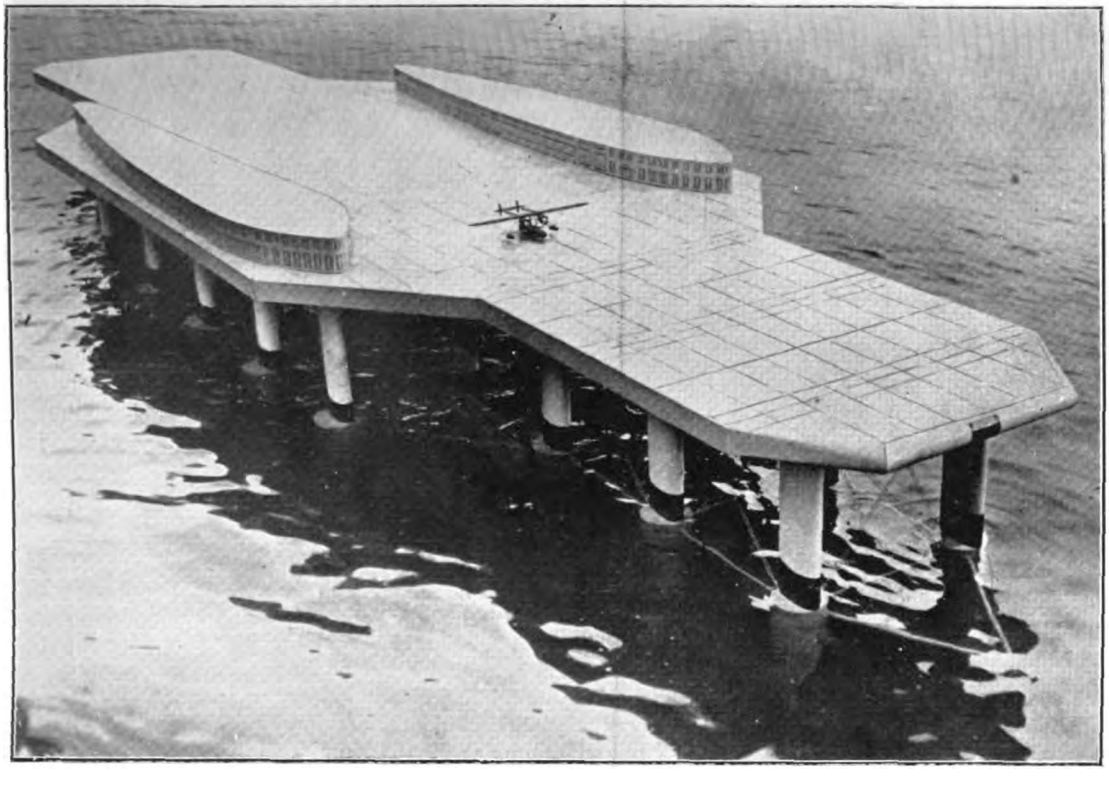

FIG. 1.—A FLOATING AERODROME.

Photograph by Wide World Photos

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FIG. 2.—THE CIERVO "AUTOGIRO."

By kind permission of the Royal United Service Institution.

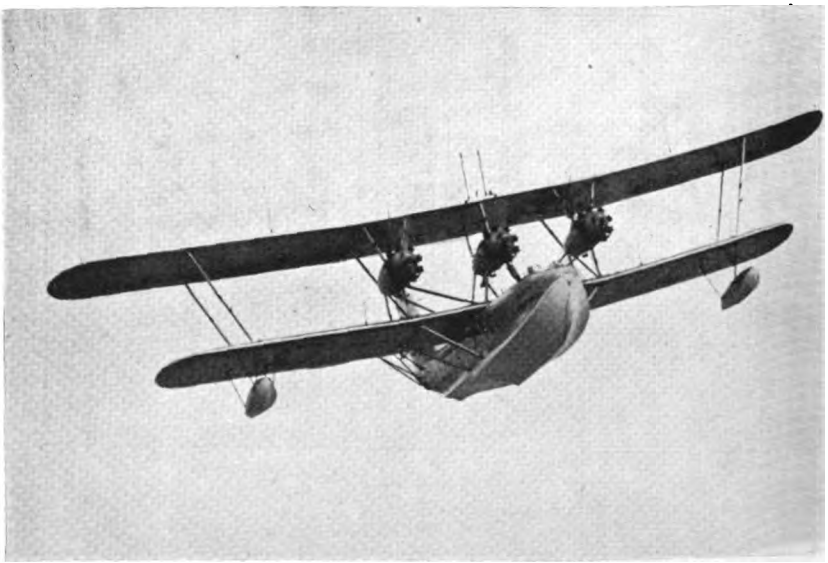

FIG. 3.—THE SHORT "CALCUTTA" FLYING BOAT

Total weight eight tons. Pay load plus crew, 4 8 0 lbs.; 14 passengers. Maximum speed, 123 m.p.h. Range, 6·5 hours at 100 m.p h. 1,390 horse-power

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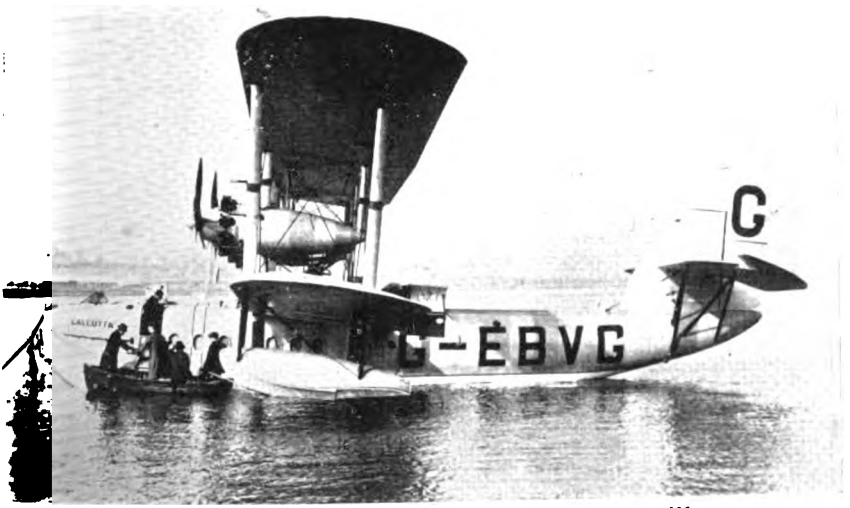

FIG. 4.—THE SHORT "CALCUTTA" FLYING BOAT ON THE WATER.

FIG. 5.—THE DORNIER DOX FLYING BOAT.

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FIG. 8.—"IN CUSTODY."

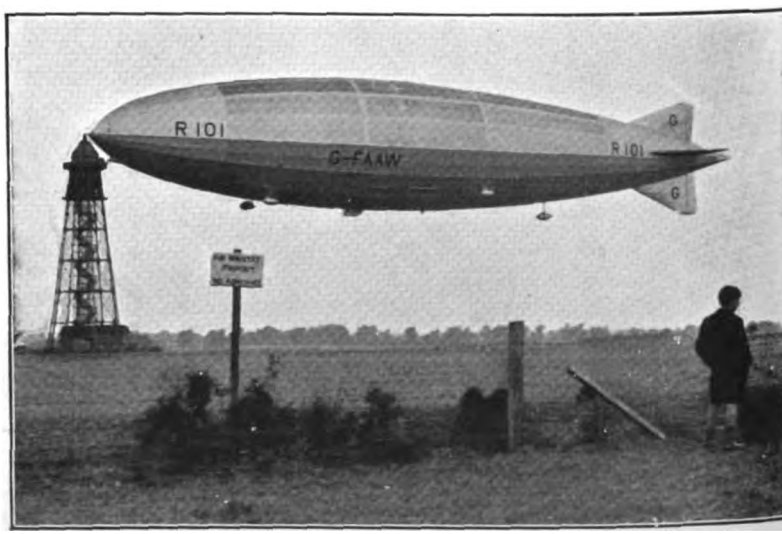

FIG. 9.—"AIR MINISTRY PROPERTY."

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FIG. 10.—A STERN VIEW OF THE R 101.—Note the fins and rudder and elevating planes. Also the " Power Eggs " and the control cabin. Each portion of the rudder is 45 feet high.

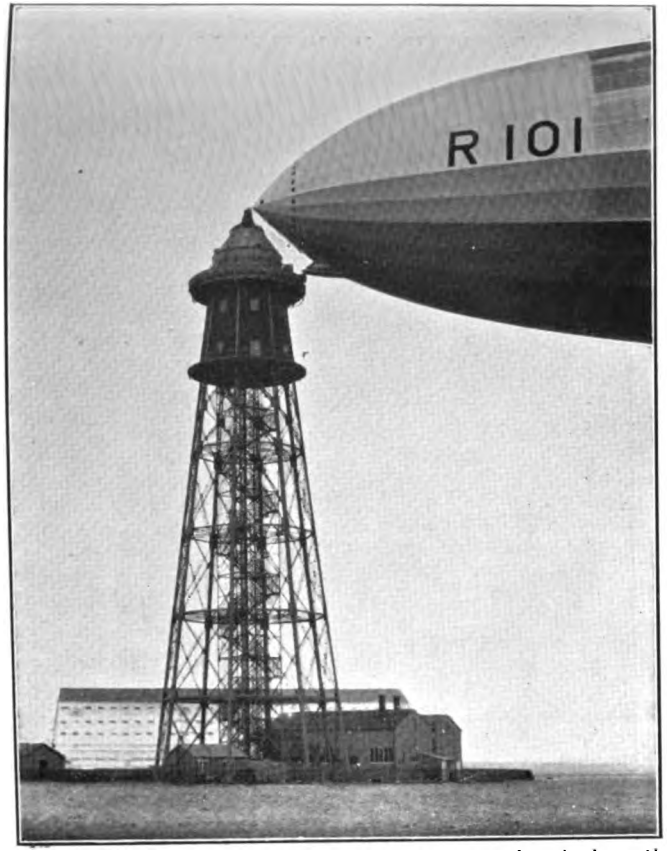

FIG. 11.—CARDINGTON.—The mooring mast, 200 feet high, with R 101 secured. Note the passenger gangway from ship to tower. A lift runs up the centre of the tower, at the top of which are installed the winches for dealing with the mooring cable

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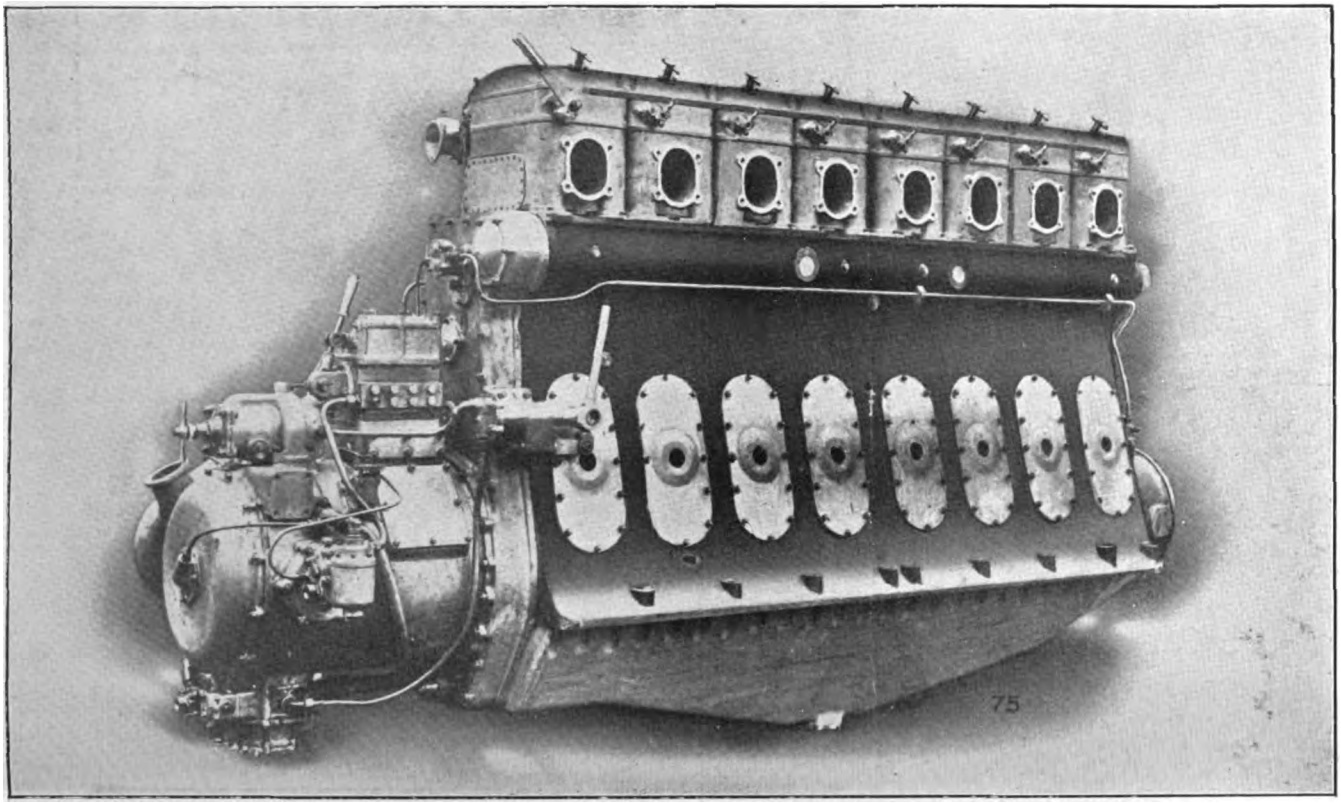

FIG. 12.—THE BEARDMORE "TORNADO" CRUDE OIL ENGINE—five of which are fitted on R. 101. 600 h.p. each.

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THE GOODYEAR ZEPPELIN SHED.

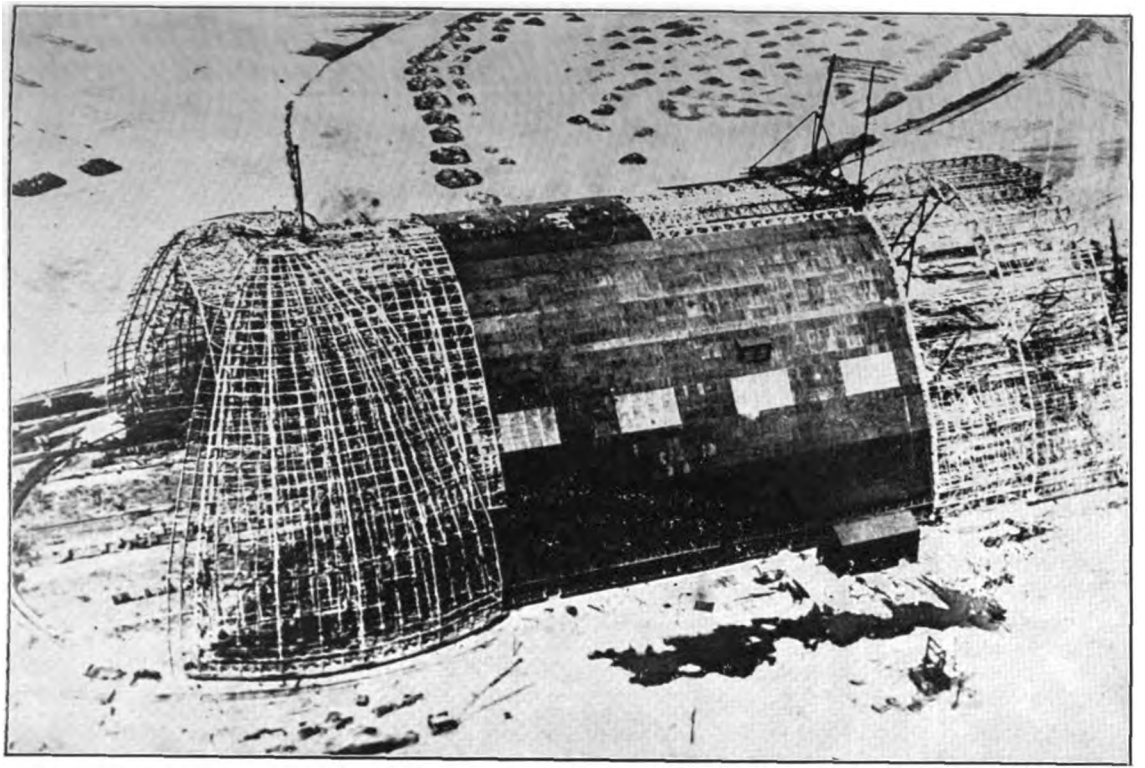

FIG. 13.—TO HOUSE GIGANTIC AIRSHIPS TWICE THE SIZE OF THE "GRAF ZEPPELIN" (1929).

An exterior view of the new giant hangar at Akron, Ohio, which will house the new American Zeppelins. Work on the first of these gigantic dirigibles will start on the 31st October; they will be of 6,500,000 cubic feet in capacity—nearly twice the size of the "Graf Zeppelin."

...graph by Pacific and Atlantic Photos, Ltd.

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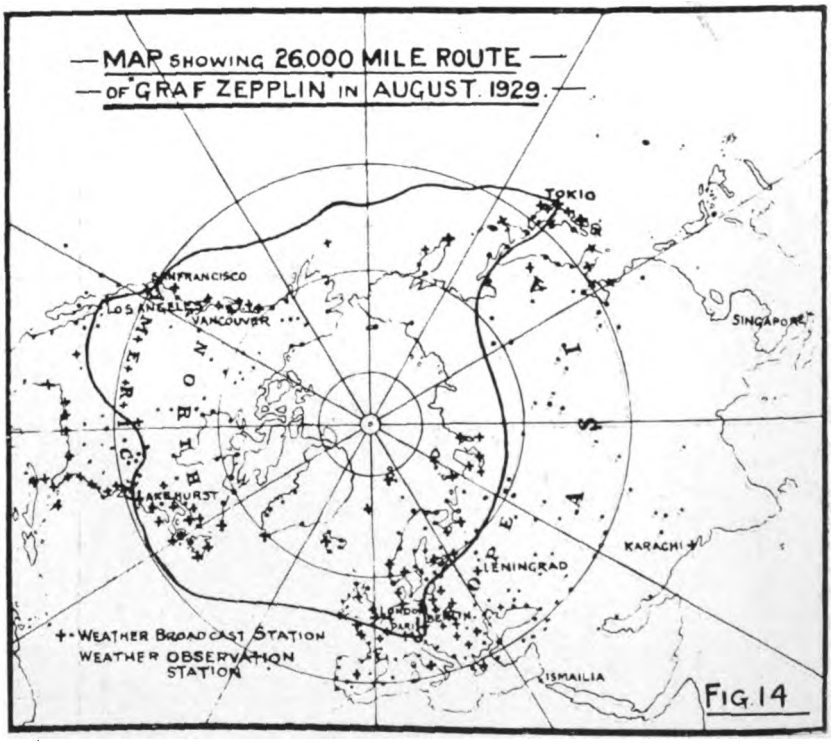

FIG. 14.

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THE WORLD'S RIGID DIRIGIBLES.

Name and Designation.	*Los Angeles.*	*Graf Zeppelin.*	*R.100.†*	*R.101.†φ*	*ZR S-4.**	*LZ-128.‡*
Nationality	U.S.A.	German	British	British	U.S.A.	German
Gas volume, cubic feet	2,470,000	3,708,000	5,000,000		6,500,000	5,250,000
Length overall, feet	658·3	776·2	695	732	785	777
Maximum diameter, feet	90·7	100·1	130	130	132·9	124
Height overall, feet	104·4	110·6	141	139	146·5	—
Kind of gas	Helium	Hydrogen & blau gas	Hydrogen	Hydrogen	Helium	Hydrogen & blau gas
Gross lift, lb.	153,000	262,000	343,000	340,000	403,000	370,000†
Useful lift, lb.	60,000	140,000	160,000	154,000†	182,000†	200,000†
Total horse-power	2,000	2,550	4,200	3,000	4,480	5,500
Kind of fuel	Petrol	Blau gas & Petrol	Petrol	Oil	Petrol	Blau gas & Petrol
Maximum speed	73	79	80	70	84†	100†
Cruising speed	—	—	—	63	—	80
Range at 58 m.p.h., miles	4,000	10,000	7,000	6,900	10,500†	—

* Two airships of this size at present building by the Goodyear Zeppelin Company, Inc., at Akron, Ohio
† Subject to confirmation on test.
‡ Construction expected to commence December, 1929.
φ Structural alterations now in hand will increase dimensions, lift, etc.

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"ILEX" IN THE FIRST PLYMOUTH–SANTANDER RACE, AUGUST, 1929.

By CAPTAIN W. G. FRYER, R.E.

ILEX had managed to finish second in the Fastnet Race, and was spending a few days rolling moodily at her buoy in Plymouth Harbour, while her crew roistered ashore. She grumbled rather, on hearing that she had only got third prize. But when, one afternoon, we hauled up her sails and turned her bowsprit to the east, she got underway with little protest. We heard a deal of mumbling coming from her forefoot, but this, we felt, was merely *Ilex* getting ready her excuses for retail to the fleet at Gillingham anchorage. "Such a shame, *Altair*, dear. We had a breeze fit to blow my side boards under, and that rough fellow, Fryer, pinched me terribly all day."

Ilex rather imagines herself the heroine of the anchorage nowadays. She always returns there with very tall stories of her travels.

In former years, the finish of the Fastnet Race has released *Ilex* from the necessity of doing any serious cruising. So that when we made for Brixham Harbour, after rounding the Start, she imagined that we were merely putting in for a good night's rest. In fact, we intended to do a little trawler racing until the Santander crew joined. This lasted for two dashing days, while *Ilex* sat on her anchor, looking very gay with all her flags fluttering about her.

Then we tried to get her back to Plymouth, to prepare for the great race. It was a passage of under forty miles, and we insulted *Ilex* by allowing her as many hours to do it in. In addition, a friendly tow was following us. But *Ilex* is an extremely capricious vessel. Just as long as we were still pointing towards Chatham and home, she continued to heel over and bowl merrily along. But, as soon as she noticed us edging her back towards the Start, she began to take charge. At first, it was only a few impatient shakes of her mainsail, to call attention to the mistake; but when we persisted in our error, she forgot all her manners and calmly, all too calmly, refused to go ahead at all. Her brisk gaiety was cast aside, her gurgling bow wave vanished, and like a spoilt child, she sat sullenly at sea off the Start.

She did worse. For five hours, we did quite a depressing number of miles backwards. Even when the tide changed, *Ilex* approached

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Plymouth at little more than an athletic snail's pace. No friendly tows were to be seen, and we became slightly concerned about our arrival. "Surely a breeze will spring up on the change of tide?" "Could we get a tow to Salcombe?" The paid hand, our ancient mariner, spotted a large number of blue jellyfish which, he stated, were a sure sign of wind.

But we were pessimistic, and put our "well-known helmsman" ashore to rout out some kind of tow as soon as he could. He is rather large, our Wilks, and the yacht he boarded went aground almost immediately. However, she made strenuous use of her tin topsail, and managed to push through. We had given up reasoning with *Ilex* by now, and did a little spirited fishing until change of tide. This is a game at which two can play. And the rocky bottom off Bolt Head played it so joyously that, when the R.E.Y.C. Treasurer, in a carefree manner, was dangling a lead overboard, it was suddenly seized in an iron grip. With a sharp yelp of dismay, he was pulled right across the ship and very nearly overboard. Bolt Head, indeed, still owes the R.E.Y.C. a very good lead and some two fathoms of line.

Night and the fog now fell upon us. The tide began to flow against us, and we dropped a hook. *Ilex* smiled smugly to herself as she tugged gently at it, because there was now little hope of reaching Plymouth in time for the race on the following morning. No doubt, she had regarded the desertion of the well-known helmsman as the act of one exasperated by her tantrums. Perhaps the fog would soon reduce the rest of us to a similar mental condition.

But we still hoped for a tow, and at intervals, we sent out odd messages through the mournful medium of the foghorn. Foghorn morse is disturbing stuff. We could make out a small yacht in the gloom beside us, which appeared to be drifting backwards with the tide. Every message we sent out with our foghorn produced a perplexed wail of "What's the matter?" from its owner. He, it seemed, from the sound of scuffling, rushed on deck at every first hoot with a heart thumping hard, through fear of an approaching steamer. Our final conversation, as he drifted slowly by, ran:

Black Blur: "What's the matter?"

Ilex: "Waiting for a tow." (It seems that he never caught this message.)

Black Blur: "I'm on a light hook out here."

Ilex: "Yes, so are we . . ."

(Pause.)

Black Blur (now reconsidering things and feeling not quite so much on a hook as he had imagined): "I'm drifting back to Salcombe."

Ilex (very heartily): "Yes . . ."

(Pause.)

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More foghorn morse, followed by sounds of panic on board *Black Blur*. Then again:

Black Blur: "What's the matter?"

Ilex: "Hullo" (as being non-committal).

(Pause. Fog very dense.)

Then faintly in the distance, our ancient mariner heard a motor horn—very active foghorn morse from *Ilex*—more panic from *Black Blur*, with enquiry as to matter—more motor horn and finally, a dim shape appeared. We now gave a further burst of morse from our foghorn and heard a further plaintive shout from *Black Blur*, who had now drifted far astern. We gave him a final cheerful "Hullo." In reply came a shout of "*Ilex*" from an approaching *Dim Shape*. We all replied together in a positively skull-bursting shout. Whereat *Dim Shape* became panicstricken, mistaking our side view with sails up for the bows of a terrific yacht about to run it down, and turned away.

Amid the enthusiastic poppings coming from *Dim Shape*, we heard the cheering voice of Armstrong, one time lord of I.C. at the S.M.E. workshops. Indeed, it was probably his crude accompaniment which first made us recognize him. The motor-boat continued its coy circling; we encouraged it with cries and finally it came to rest alongside. It *was* Armstrong, and we raised a great cheer, helped out with energetic pumping of the foghorn. He was on *Fulmar*, when she blew out her mainsail on the Heligoland cruise, and one has come to expect wild weather and exciting sailing when he comes aboard.

We now pulled furiously at the anchor and passed a warp to the motor-boat. "Ready?"—"All ready." Chug, chug, chug.

For the next nine hours we were towed over the local ocean at high speed. Blank, grey curtains hung around us. From somewhere ahead came the steady chugging of the motor-boat, but the fog was too dense to make it out. We kept a hand forward on the bows to shout directions to the helmsman. Towards midnight the fog overhead grew thinner and the moon gave out an eerie, pallid light upon the grey twenty-yard circle that was our visible world. One lost all sense of horizon and earth contact. As one sat at the tiller, *Ilex* seemed to be gliding dreamily down an unending hill of eternal greyness. Throughout the night, there was no breath of wind to disturb the perfect flatness of the still sea.

In the early hours of the morning, we recognized the black shape of Rame Head. It loomed up from the mist and gulls screamed an anxious warning at us. With the sun rising over Plymouth, we made fast our buoy and paid off the motor-boat.

It was 7.30 a.m., and we felt as if we had been steering for a whole age instead of one foggy night. The race to Santander was due to start in four hours. We had to provision and water ship, collect our

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crew, and get *Ilex* under way and in ocean-going trim. We considered this for a little and fell asleep with the cold fog rime still on our hair and faces.

Much stamping on deck brought us back to the urgent matters of the day. We worked in a crescendo of activity. While our rivals were cruising around with little to do except adjust the set of the burgee, *Ilex* did her final furious stow. Wilks, our "well-known helmsman," came aboard with the dinghy only ten minutes before the starting gun. And so we made a bad start. We crossed the line eighth, with most of the crew rushing madly around the vessel, still trying to cure a lunatic form of jackyarder disease. The other starters were :—

Jolie Brise.
La Joyeuse.
Maria del Carmen. (Another and bigger yacht of this name raced in, and won, the larger class.)
Guerveur.
Grey Fox.
Ettsi IV.
Neptune.
Avocet.
Magnet.

We looked upon *Jolie Brise* as the favourite—she has won the American Ocean Race once and the Fastnet Race twice—and she got away at great speed. The small *Maria del Carmen* and *Neptune* appeared to be the fastest yachts in our class, and they went off with *Jolie Brise* rather to the west of our course.

We now had a little breathing space in which to count the crew. Two watches were picked. D. Hunt, who was doing skipper and navigator, decided to form a watch with M. T. L. Wilkinson, and Rupert Brown. Hunt, therefore, had rather a heavy task during the race. We had not been able to collect a larger crew, owing to the delay in the fog. In the other watch were Major S. J. Armstrong, W. G. Fryer and G. D. McK. Sutherland. Carter, our ancient mariner, cooked.

Ilex had now forgotten her bad temper and evidently intended to make the best of things, when she saw so many old friends heading on the same course. But our bad start was quite noticeably depressing the skipper, even though we had already much improved our position. Fortunately, the topsail sheet suddenly cast itself off at this point. And the excitement of climbing out to the end of the gaff and re-reeving it *in situ* with a merry breeze blowing quite restored his good spirits. Energetic skippers, like Hunt, must always be given some such trial as this, or they imagine that yachting has degenerated into a girlish pastime.

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The crew is working out a scheme for next season's race. It is to work like this. . . .

Pale and anxious face rushes up from below. " She's leaking like hell ! Carter says the keel bolts need tightening from below." And so we feverishly collect an immense spanner, a long rope, and rush up to the skipper with them. He beams with gratitude, makes himself fast, takes a deep breath, and is lowered down from the bows with a rush. And while he sweeps under the vessel, he does the job. This, we feel, would amuse him for the rest of the race, and the idle hands will be able to work out D.R. (dead reckoning) in peace.

Throughout the day, we sailed with the wind just comfortably free on the port bow. Both jackyarder and yankee jib were set and did great work. We logged six knots for most of the day, and the sun made it very pleasant sail.

Working out D.R. became the euphemism on *Ilex* this year for any kind of idling—especially idling of the cat-nap kind. It arose from the curious habits of Wilks, our 7.65 knot man and well-known helmsman.

Wilks seldom takes any real interest in the navigation proper. His chief concern is to see that all the big mileages are done during his watch or his hour at the helm. He refers to himself grandly as the 7.65 man, in memory of the day in this year's Fastnet Race, when nobody else could make *Ilex* do more than seven knots. (Some of us have grave doubts about the correctness of that log reading, but Wilks has been a prouder man ever since.) After a siesta below, Wilks comes on deck with an apparently authoritative statement as to *Ilex's* position. This is usually very much to everyone's surprise, as we know that he has not been to the chart nor seen the log readings. But Wilks always thinks it necessary to give some position, just to show that, although he was lying down with his eyes closed so peacefully, yet that busy brain was working at high pressure on affairs of the greatest importance.

At nightfall, we sighted Ushant white light on the port bow. There were no yachts at all near us now, and we spent the night about ten miles off Ushant making little headway. We had no long anchor line, and did not go in closer lest the tide should carry us too far from our course. Many of the leading yachts were caught in a calm nearer Ushant next morning.

Dawn is always an exacting time in an ocean race. This dawn broke fine and clear, with a variable light southerly wind, and it showed us *Avocet* astern, *La Joyeuse* abeam to leeward and *Guerveur* just ahead. This was fairly good going as *Ilex* was the smallest yacht in the race. We raised a cheer and brought the gramophone on deck. Then we changed the yankee jib for the small jib topsail. Then we changed them again once more. As a result, we passed *Guerveur* and dropped the others out of sight behind.

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Maria del Carmen, a fine-looking staysail schooner and the largest yacht in our class, now came out from the north-west like a race-horse. She crossed our bows on the other tack and went ahead at great pace. This startled us somewhat, for when we saw her at the start of the race, she had shot ahead of us in exactly the same way. Somebody suggested that perhaps she was on her second round. It almost looked like it. *Grey Fox* also appeared from the same direction and remained in sight for the rest of the race.

When the skipper had taken his midday sight, *Ilex* picked up a better wind, and sailed full and bye on her course to Santander. The sun was hot, the sea and sky a wonderful blue. Costumes were principally by Adam; beards were of moderate length. The gramophone managed to play us sea shanties without being greatly affected by the ship's motion.

That night (Tuesday), we met the pirate ship. Even now we do not know what she was. Most probably, she was an inquisitive trawler or a pilot vessel. It was a jet-black night and we first spotted her as a white light on the bow. The wind was getting rather more free, and so we got ready the balloon staysail. *Ilex* was now doing about 6½ knots with her sheets eased. The white light came nearer and nearer, until we could make out a huge black hull beneath it. There was no doubt that it was steering directly for us. We looked at all our navigation lights and waved a torch. Still she kept on. At last, we were forced to bear away. She altered course to meet us! We then bore away hard and just passed across her bows with great relief. She altered course after us, but we went away at speed. Perhaps she was a well-known bore of these seas and was looking for a victim. For the Bay is a lonely spot.

The deck chatter during this little struggle was horrifying stuff for the watch below to listen to, and they quite lost their keenness for working out D.R. It was an unpleasantly close shave on such a black night and at such a spanking pace.

For the rest of the cruise, our watch regarded any approaching white light with extreme suspicion. So that when, on the return cruise, we spotted a similar white light on the horizon, we watched it carefully. "Yes, here it comes! Getting higher and brighter every moment. Just the same black night. We'll fairly shake it up with the Verey pistol this time, tho'!" And it was not until Sutherland's furious search for the pistol had brought the watch below to the exciting stage of hanging on the bunk side ready for the bump, that the light was recognized as Venus, rising rather more superbly than usual. We handed the watch below a few towels to wipe the sweat from their brows.

Throughout Tuesday night, *Ilex* rushed ahead into the blackness, with all sail set. Shortly after the pirate ship scare, the moon rose grand and clear. By then we were so suspicious of white lights, that

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the helmsman was only just in time prevented from luffing up to avoid it.

When the next watch came on, *Ilex* was heeling well over under her jackyarder and newly-set balloon staysail. But immediately the 7.65 man came up, he began in melancholy manner to put the yankee jib into stops. And shortly, wild cries, borne down to our bunks below, warned us that somebody had fallen overboard, or else that *Ilex* was adding still more frills to her toilet. We went on with our D.R.

At daybreak, we made out *Grey Fox* still astern. No other yachts were to be seen, and *Ilex* gave us a wonderful sailing day in her anxious search for more company. The sun shone brilliantly upon the warm, blue waters of the Bay, and we decided that we might forgive *Ilex* for her tantrums off Bolt Head. It was now Wednesday —the third day of the race—and we expected to see the Spanish submarines which were patrolling this part of the course. To-day we met our first tunnyman. She was painted green with dark-yellow sails, and was a very pleasing sight as she bowled along with her 70-foot fishing rods out on each side.

Towards evening a glassy grey calm took the place of our gay sailing breeze, and we saw a submarine, C.3, making for us. We decided to check our G.M.T. as the wireless sets had refused, with loud and continuous howls, to give any help in this important matter.

And so some of us staggered on deck with the code book and the signal flags, while the rest lay back and prepared to give advice. C.3 played up superbly. She even developed the precocious habit of answering our signals before we had finished hoisting them up. She came closer, and finally, some crude French and a megaphone produced the required check. We had doubted our chronometer without reason.

Wednesday night was completely calm. There was just enough swell to keep the boom banging about in an irritating manner. The patent log became quite despondent about it and the line hung vertically downwards in a long, phosphorescent blaze.

The yankee jib, our lightest sail, seemed willing to draw at times, but the continual rolling shook the wind out of it. And so the skipper decided to hoist the spinnaker in place of the mainsail and jackyarder. This was done, and *Ilex* seemed to shake very much less. The long line showed activity on several occasions after this change, but we really moved very little throughout the night. For some time, *Ilex* insisted on pointing back towards Plymouth, but this was only in the worst of the calm.

It was an admirable opportunity for some work by our navigation night school. All the stars were readily recognizable. Even those

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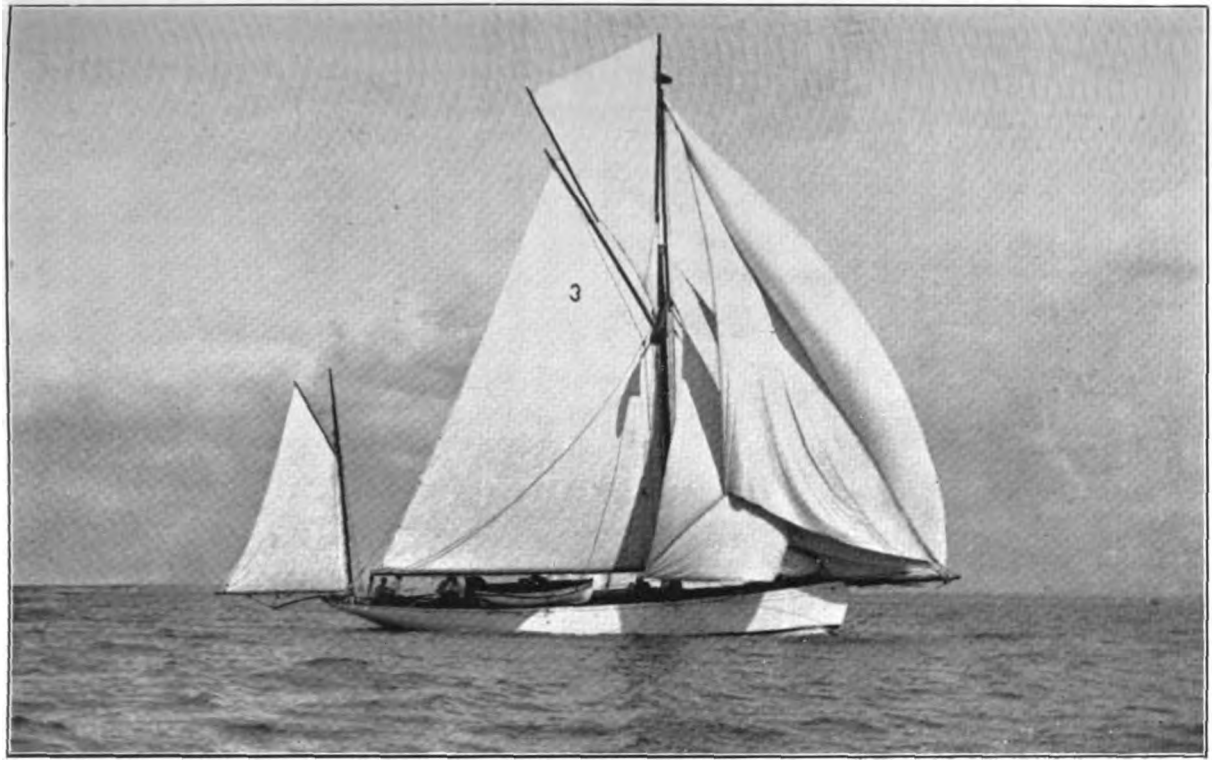
"ILEX" IN THE FIRST PLYMOUTH-SANTANDER RACE, AUGUST, 1929.



"Ilex" off Spithead, 1929.

Photograph by Beken & Son, Cowes.

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Spanish Ocean Racing Kit.

A Fair Wind.

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of the most meagre brilliancy ran quite a considerable risk of having their Christian names bandied about the vessel. By dawn the skipper had the ship's position fixed by quite a comforting number of sights on them.

The rising sun brought a gentle wind from just forrard of the port beam. It was time to replace our odd Bermudian rig. Down came our spinnaker-mainsail and up went the main and jackyarder once again.

Long rollers were coming up from the north-west, and *Ilex* went along quite fast on the calm sea. There seemed to be about 100 yards between wave crests, and they rolled ponderously past us like a shoal of enormous sea serpents. After breakfast, our good friend, C.3, very fussy with her terrific klaxon horn, came to see us once more. We decorated *Ilex* with a garrulous array of signal flags. Back came the reply: "*Jolie Brise* and *Neptune* ahead of you." We knew that *Neptune* allowed us an appreciable amount of time, but there seemed little hope of beating *Jolie Brise*. Still, there was a great chance for second prize, and we brought the gramophone on deck once more. It did stout work throughout the day. Most of us can now hit off the chorus of "Wake up, chillun" at the first shot. Our conversation became brighter every moment. We all said several times how wonderfully blue the sea was.

Throughout the day, we kept up a good speed. After tea, we saw that *Grey Fox* astern seemed to be pointing up to the eastward. The skipper speedily took about ten shots at the sun, and these seemed to show that we should keep straight on. We did so, and strained our eyes in the search for "snow-clad mountains, often visible 70 miles out at sea."

Our ancient mariner suddenly saw land out towards the west. This might have depressed any navigator, who was unacquainted with his lively imagination. However, he failed to identify the Statue of Liberty, and found land both ahead and to the east instead.

And then Brown spotted a twinkling light just under the bowsprit. Land ho! Hunt timed it from the masthead. It could only be Cape Mayor light—on the Santander headland. It was 6 p.m. and 9in time. We felt that this was superb navigation, and drank bad luck to all navigators who insist on making landfalls in the early hours of the morning.

Night fell, but still *Ilex* rushed amiably at the light. A voice spoke, "I expect *Jolie Brise* is in by now." Immediately the easterly wind died away and we had to hold the boom still once again. We said many horrid things about leader's luck. Actually, we should not have made up our time on *Jolie Brise* even if the wind had held throughout the evening. C.3 once more came up in the dark and we made our name to her with the help of a small pocket torch.

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Progress was slow. At midnight, it began to get thick. In the early hours of Friday morning, we could only just make out Cape Mayor light, and the lights on a large ship anchored in the harbour entrance. At 1.30 a.m., a light westerly breeze sprang up and we crossed the finishing line at 2.42 a.m. For the previous hour we had been burning flares and firing Verey lights. No one replied, although a number of lights were visible from *Ilex*.

Having crossed the line, we reduced sail in the fog, and then sailed back to the lighted ship, to discuss the matter of a tow to some suitable berth. Our first venture into the harbour had brought us the sound of breakers ahead in the fog. With a torch, we signalled questions in Spanish, French and Latin to the markship. Finally, she made out our torch light and suddenly replied in English, a language which we had not thought worth trying, " What do you want ? "

It then took about ten minutes' wild flashing to make it appear that we were talking to H.M.S. *Royal Oak*. This seemed idiotic, so we gave up the matter and sounded our way in the gloom towards the breakers on the nearby beach. There we anchored for the night, rolling deplorably in the swell.

The fog remained thick until the day was well advanced. A submarine anchored beside us and gave out melancholy fog signals at short intervals. The swell made sleep difficult in any case ; one had to retain sufficient consciousness to wedge oneself up against one side of the bunk.

At 8 a.m., we gave up the struggle and went on deck. We made out a large town, a wonderful beach, a ridge of nasty-looking rocks, and a dead shark with a baleful look in its eye. All of them seemed to be unpleasantly close—particularly the rocks. Anchored astern was *Grey Fox*, a British battleship and *Neptune*, with sails still up. Evidently *Neptune* had come in after us, as otherwise we should have seen her while sounding up to our anchorage. " Perhaps *Jolie Brise* had come in with her ? "

There was much excitement at the possibility. We bathed, and one of us even washed and shaved himself in readiness for the shore. A pinnace from H.M.S. *Royal Oak*—for our yeoman of signals had been right, though not even he had believed it—very kindly helped in the matter and the Real Yacht Club house was discovered.

On landing at the Club steps, the first people to be recognized there were the crew of the *Jolie Brise*, looking as smart as if they had finished the race at least a couple of days ago. They had come in at 8 p.m. the previous evening, just before the wind dropped, having sailed an excellent race.

H.M. The King of Spain is one of the most enthusiastic yachtsmen at Santander. He showed great interest in our general fortune in the

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race. He had given the first prize for the larger class, which had finished before ours, and had been won by the immense ex-*Meteor*, now renamed *Maria del Carmen*. *Ilex* had, however, managed to beat one of the larger class, though not a very speedy one. It soon appeared that *Ilex* had very probably won second prize.

The fog had made finishing times very difficult to take. But it was soon clear that the small *Maria del Carmen* had crossed the line about half an hour before us. This meant that *Ilex* finished third and got second prize by a considerable margin.

The prize-winners in the smaller class were :—

1. *Jolie Brise* (H.M. The Queen of Spain's Cup).
2. *Ilex*.
3. *Grey Fox*.
4. *Guerveur*.

The prizes were extremely good. H.M. The Queen of Spain presented them in person at the Real Yacht Club. The gold cup which *Ilex* obtained for second prize is so large, that it had to be stowed in a sail locker. It now decorates the H.Q. Mess. Inside the cup we found notes for 3,000 pesetas, with which the Treasurer promptly disappeared.

Spanish hospitality is superb. We spent some wonderful days at Santander, waiting for the prize-giving and official dinner. The members of the Real Club Maritimo Santander entertained us wonderfully well the whole time.

And now we are all discussing next year's race. Hunt, we hope, will still be available. We may not win such a large prize, but we are certain of a most amusing time. Who is for sailing south to Spain next August ?

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THE ELIZABETHAN CHRONICLE PLAY AS WAR PROPAGANDA.

By COLONEL B. R. WARD, C.M.G., Hon. Secretary, The Shakespeare Fellowship.

THE history of the rise and decline of the chronicle play in the sixteenth century has been treated up to the present as a literary question pure and simple.

Clemence Dane, in the last act of her play, *Will Shakespeare*, illustrates this by a fine soliloquy she puts into the mouth of Shakespeare as he sits down in the Palace just after Marlowe's murder in 1593 to write *As You Like It* under the Queen's orders. A page enters with lights and announces himself thus :

> The Queen, sir,
> Has sent you candles, now the sun is down,
> That you may see to work.
> SHAKESPEARE. I thank the Queen.
> Tell her the work goes well !
> *He sits down at the table.*
> Act one, scene one,
> Oliver's house. It *shall* go well. I have
> A strength that comes I know not whence. It *shall*
> Go well. And then I'll give the Roman tale
> I heard at school—a tale of men, not women :
> That easies all. But Antony goes on
> To Egypt and a gipsy : leaves his pale wife
> At home to scald her eyes out. Mary—Mary—
> Will you not let me be ? It *shall* go well.
> And after Antony some Twelfth Night trick
> To please our gods and give my pregnancy
> Its needed peace. How many months for Denmark ?
> And then ? A whole man laughs, and so will I.
> Oh, Smile behind the thunder, teach me laughter
> And save my soul !
> The knock-about fat man, try him again !
> He'll take a month or less—candles are cheap,
> Cheaper than sleep these dreaming nights. That done
> I'll sink another shaft in Holinshed . . .

Shakespeare is here thinking of all the plays he intends to write. He has already written *Romeo and Juliet* and the *First Part of*

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Henry VI., and with *Richard II.*, *Richard III.*, or perhaps *Henry V.* in his mind's eye, he suggests to himself the sinking of another shaft in the rich mine of Holinshed's *Chronicles*.

Will Shakespeare is described by Clemence Dane on the title page as *An Invention in Four Acts*, and a fine piece of inventive work it is, that thoroughly deserves its popularity both on the stage and as a fantasy to read with one's feet in the fender. But invention is not history, and since the play was first acted in London on 17th November, 1921, historical research has thrown a flood of light on the origin and development of the Elizabethan Chronicle play. The details of this research are recorded for the most part in literary and other journals in the form of notes and articles that have not yet been woven into a coherent and continuous narrative. In the following pages an attempt will be made to trace the history of the sixteenth century chronicle play, and to show the place it occupies in the general history of the time.

In early mediæval times the miracle play was the only form of dramatic entertainment. These plays were performed by trading-companies in the various towns, Chester having set the example by a series of plays acted at Whitsuntide at the close of the thirteenth century. The religious drama was particularly at home in East Anglia; Wymondham, Norwich, Sleaford, and Lincoln being famous for such representations.

Miracle plays represented incidents from the Old and New Testament, and were performed under ecclesiastical authority. They gradually gave way to allegorical plays known as "Moralities."

> "The transition from the morality to the regular drama in England," writes Professor A. W. Ward in his article on "Drama" in the *Encyclopædia Britannica*, "was effected, on the one hand, by the intermixture of historical personages with abstractions—as in Bishop Bale's *Kyng Johan* (c. 1548)—which easily led over to the *Chronicle History*; on the other, by the introduction of types of real life by the side of abstract figures."

The next advance in the evolution of the morality was made by John Heywood, whose "Interludes," or short farces in the French manner, were the direct precursors of what we now call "Chronicle Plays," but which continued to be known as "Interludes" throughout Elizabeth's reign.

The first real chronicle play was *The Famous Victories of Henry V.*, first printed in 1598, but as recent research has shown, first acted before the Queen at Hampton Court during the Christmas entertainments of 1574. The moving spirit at the back of this interlude or chronicle play which ushered in the famous series of Elizabethan historical plays was a young nobleman in his twenty-fifth year, Edward de Vere, Earl of Oxford.

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In later years, Oxford's great friend, Lord Lumley, when discussing the drama in *The Arte of English Poesie* (1589), wrote : " For Tragedy, Lord Buckhurst and Master Edward Ferrys do deserve the highest price : the Earl of Oxford and Master Edwards of Her Majesty's Chapel, for Comedy and Interlude." It is not unlikely that Lord Lumley was here thinking of that stirring and at the same time amusing interlude, *The Famous Victories of Henry V.*, which had been acted in its earliest form fifteen years previously.*

The Earl of Oxford, who had married Lord Burghley's daughter in 1571, soon began to tire of Court routine, and what must have seemed a humdrum home life under the somewhat ponderous influence of his father-in-law. In October, 1572, writing from his country house at Wivenhoe in Essex, he acknowledges a letter from Lord Burghley, " the first I have received of your Lordship's good opinion conceived towards me," and goes on to hope " with your Lordship's indifferent judgment to be more plausible unto you than heretofore, through my careful deeds to please you, which hardly, either through my youth, or rather my misfortune, hitherto I have done."

A month before this, he had been applying to his father-in-law to use his influence on his behalf to allow of his volunteering for service at sea. " If there be any setting forth to sea, to which service I bear most affection, I shall desire your Lordship to give me and get me that favour and credit that I might make one. Which, if there be no such intention, then I shall be most willing to be employed on the sea coasts to be in a readiness with my countrymen against any invasion."

For the next two years Oxford was kicking his heels at home, and was obliged to content himself with literary work. It is not unlikely that the Queen had something to do with the want of success of his volunteering efforts, for as young Gilbert Talbot wrote to his father, the Earl of Shrewsbury, on 11th May, 1572 : " My Lord of Oxford is lately grown into great credit, for the Queen's Majesty delighteth more in his personage and his dancing and valiantness than any other."

However that may be, he stuck it out for a couple of years ; but at last—in June, 1574—being unable to obtain naval or military employment, and permission to travel abroad being also persistently refused, he took the law into his own hands and ran away to the Low Countries, where he visited the Spanish entrenchments before Bommel, before the burghers raised the siege by cutting the dykes. This schoolboy escapade ended ignominiously. A Queen's messenger was hastily dispatched to bring back the defaulting courtier, who hurried to Gloucester early in August to make his peace with the Queen, who was then on a Progress in the West Country.

* The circumstances of its original production were first brought to light in an article contributed to the *Review of English Studies* in July last year.

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The Queen seems to have borne no resentment against her young favourite, who spent the autumn with his Countess at Hampton Court, where no doubt he continued to delight Her Majesty " with his dancing and valiantness."

The Christmas entertainments at Court required considerable preparation beforehand, and it is probable that, very soon after the interview with the Queen at Gloucester, the idea must have entered Oxford's mind that he could not do better than set to work to gain the Queen's approval to his application to travel abroad by means of a topical interlude.

Although we do not possess a complete record of the Christmas entertainments at Hampton Court in 1574, there can be very little doubt that the *pièce de résistance* on that occasion was an interlude written by Lord Oxford on the subject of the youthful escapades of Prince Hal, followed by his heroic action as King Henry V., the victor of Agincourt. The 11th Earl of Oxford comes into the picture as King Henry's Earl Marshal, and is given a much more prominent role than the chroniclers ever assigned to him. There can be little doubt that the part of Prince Hal was taken by Oxford himself, who had a magnificent opportunity to display that " valiantness " of his in which the Queen so much delighted.

The success of the play and the pleasure which it must have given to the Queen may be confidently assumed from the fact that Oxford's licence to travel abroad received the Royal sanction early in the New Year, and that on 7th January, 1575, he started on his long continental tour, with Paris as his first destination. The Queen had been unable to resist the application, driven home as it was by the comparison between Oxford and Prince Hal.

After spending sixteen months abroad, Oxford returned to Court life and Court dramatic entertainments. In 1583, a company of twelve actors was selected and named the Queen's Players, the element of professionalism thus introduced marking the increased importance attached by the Queen to Court dramatic entertainments. It is also possible—for Queen Elizabeth was a very far-sighted person—that she foresaw the importance of the role that the public stage might fulfil when the long-expected rupture with Spain should take place. At any rate, we know that *The Famous Victories of Henry V.* was one of the plays performed in public by the Queen's players in the late 'eighties.

In 1585, the long-expected war was declared, and the Earl of Oxford was sent to the Low Countries in August at the head of an Expeditionary Force of 4,000 men to assist the Dutch against the Spaniards. Within six weeks, Oxford was mysteriously recalled, and the Earl of Leicester was appointed Lieutenant-General of the English Forces in the Low Countries.

It seems probable that Oxford was recalled by the Queen in order

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to take charge of a Secret Service Department of State, for, from June, 1586, to his death in 1604, he was in receipt of a grant of £1,000 a year from the Exchequer. No account was to be called for as to how this money was expended. It was a grant for Secret Service purposes.*

The Anglo-Spanish War lasted for twenty years, the peace negotiations being in progress at the time of Oxford's death in 1604. Only once in the whole period did the expenditure on the Army and the Navy drop below 50% of the revenue. In the Armada year the figure was 101%, the average annual expenditure during the whole period of twenty years being 72%. During this time, taxation increased four-fold, food prices were trebled, and there was a threat of famine in 1596 and again in 1597. It is interesting that practically identical statistics recurred during our war with Napoleon, and again in 1914–1918.

It is, therefore, practically certain that Oxford's £1,000 a year, which exactly covered the war period, was granted for war purposes, the special purpose being almost certainly the dissemination of propaganda by means of literature and the stage.

It was during this period that the Chronicle play attained its greatest popularity. After the peace with Spain it was hardly ever revived. The earliest chronicle play was, as we have seen, *The Famous Victories of Henry V.*, acted in the 'eighties by the Queen's Players. This play was afterwards expanded into three exceedingly popular plays—*Henry IV. Part I*, *Henry IV. Part II*, and *Henry V.* The last-named play, which was first printed in 1600 towards the end of the Anglo-Spanish War, is the last of the great chronicle plays. It is interesting to trace its history back to the Earl of Oxford's Court interlude of 1574. Did he, as Director of War Propaganda, feel in 1600 a twinge of satisfaction at the thought of the great literary result that had been achieved by his early comedy? In 1574, his idea was to influence the Queen in favour of his application to travel on the Continent. Since then, his witty interlude had been developed into a great national series of dramas which had had no inconsiderable share during the strenuous war years in the work of influencing the people of England in the direction of loyalty, patriotism, and the will to conquer.

* See *R.E. Journal*, December, 1928, page 658, "Shakespeare and Elizabethan War Propaganda."

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A VISIT TO ORAKAU BATTLEFIELD.

By LIEUT.-COL. J. E. DUIGAN, *New Zealand Staff Corps.*

ON 25th August, 1929, a meeting of officers, doing a Senior Officers' Course, in Cambridge, was organized, to meet the two remaining veterans of the Battle of Orakau, fought during the Maori War. This battle was fought in 1864, between some 300 Maoris, who occupied a strongly entrenched position, and a British force of 1,800 men, composed of the 18th Royal Irish, 40th Foot, 65th Regt. Royal Artillery, Waikato Militia, Forest Rangers, and Colonial Defence Force Cavalry, under Brig. Carey. The battle lasted three days. There were two unsuccessful assaults on the Maori position on the first day, after which a sap was carried towards the *pah*. On the third day, Maj.-Gen. Sir Duncan Cameron arrived and took command. During the afternoon, before the final assault, the Maoris were called upon to surrender and gave the famous reply: "We will fight you for ever, and for ever, and for ever," which has become the motto of the present Waikato Regt.

The Maoris were led by Rewi Maniapoto, and came from tribes located near Kihikihi, the King Country, Taupo, and Urewers districts.

After the British terms had been refused, the Maoris were called upon to send their women out of the *pah*. The women's reply was: "If the men are to die, we will die, too."

The following is a brief outline of the description of the battle as told by Te Huia Raureti, the other veteran not being able to come owing to sickness. In order to get certain information, the following questions were put to Te Huia through the interpreter:—

1. When did he come to the *pah*?

Te Huia said he first came to the *pah*, in Orakau, in the days when his people congregated there.

2. How old was he?

When war broke out, he was a married man with children. He says he is now over 100 years of age.

3. How was he dressed and armed?

In those days, he said he was dressed in the ordinary shirt, and was with a double-barrelled gun. Te Huia remarked that he had left his trousers behind, which caused some laughter.

4. How did he carry his ammunition?

He had two belts on, each with 10 cartridges in one portion and 10

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in the other, making a total of 40 cartridges in all. It was a proper cartridge belt with leather flaps.

5. Did he help to dig the trenches ?

Yes. He said the trenches were dug with ordinary spades, but they had only very few. They dug the first day and part of the night.

6. Where was he posted in the *pah* ?

He was posted near the south-east corner.

7. When did he first see the soldiers ?

The first of the Pakeha soldiers appeared early in the morning, when it was just breaking day. There were only a few at first, but after a while more and more appeared, and the Maoris wondered where they were all coming from. They appeared in all directions.

8. Describe the soldiers' attack.

The Maoris opened fire on them at first and then let them come as close as desired, but, unfortunately, an old peach grove obscured their view, as the soldiers kept well behind it. Te Huia said the soldiers were very brave and fearless.

9. Did any fall close to the *pah* ?

Yes. One of them, who was very high up in rank, was killed there.

10. Were they carried off ?

The soldiers tried hard to rescue him but, as fast as they approached him, fire was opened upon them, and they had to go back. Eventually, however, some of them made a rush and tied a rope round the dead man's leg and then dragged him in that way.

11. Were any Maoris hit close to him ?

Yes. One Maori, who was standing in the corner of the *pah* near Te Huia and his father, was looking over the parapet to try if he could see anything, when he was shot in the mouth and killed.

12. What did they do with their dead and wounded ?

Te Huia replied that they just covered them with a little earth, as they had no time to dig graves. One Maori was a great hero. He used to walk round the top of the parapet all day and tell the others what was going on until, at last, one night, he was wounded very severely. They made him comfortable in a dug-out, but he did not linger long.

13. How were they fed ?

The Maoris had no time to make proper provision for food and just had to steal out at night and gather potatoes from a pit, which had been left outside the *pah*. They were also able to get *kumikums*, a species of marrow. Unfortunately, they had no water, but used to quench their thirst on the juice which they got from the pith of the *kumikums*.

14. Could he see the sap ?

Yes. Te Huia said there was a small outwork outside the big *pah*,

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and they were able to see the sap quite well. The soldiers were very wise and dug a trench from where they were obscured by the peach grove.

15. Did he see the interpreter, Capt. Mair ?

Yes. One of the soldiers asked the Maoris to surrender, so that they could save their women, but he had hardly finished speaking when Te Huia noticed an old man getting ready to shoot him. Te Huia said, by the time he got to this old man and told him not to shoot, the man had fired but missed. The Maoris said that if the *Pakeha* went home, they would leave, too.

16. How was the message to retire given ?

Te Huia said he really could not say. When the soldiers commenced bombing the outwork, the Maoris there came rushing over the parapet into the main *pah*. They seemed to scatter all of a sudden. There was a gateway in the south-east corner of the *pah*.

17. Were there women in the *pah*, and how many ?

Te Huia, after naming them to himself on his fingers, said there were about twelve women there, including two lovely girls, and his old eyes twinkled. One of them was a half-caste and one a Maori.

18. What were their duties ?

They had to do the cooking and carry provisions of food. They acted as drays.

19. How did the Maoris treat bullet wounds ?

The Maoris had no herbs with which to treat wounds inside the *pah*, but when they got hit, they had to rip off their shirt sleeves, or something else, and use them until they got home again.

20. Where did they meet the soldiers of the 40th ?

He could not distinguish one regiment from another, but the troopers on horseback galloped around in a circle to try and cut the Maoris off. Te Huia recalled that his father fired at an officer or trooper and shot his horse, but the man got away. There were seven Maoris in one group, but all of a sudden, thirteen soldiers appeared. The seven Maoris, of which Te Huia was one, were told that Rewi, their leader, was coming through the scrub behind them and they were waiting to cover his retreat. His uncle told him to be careful and they would wait and watch and get ready, so that as soon as the soldiers appeared, they would fire on them. When the Maoris fired, some of the troopers got right on the sides of their horses and escaped from them.

21. When did they last see the soldiers ?

After that they saw no more soldiers.

22. Did the guns do much harm ?

Te Huia said the soldiers had some big guns on a ridge called "Kariponia," which was meant for "California," and they were the ones which did all the damage. The soldiers may have had one gun

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in the sap, but he did not think it was ever used, as it would be impossible to fire effectively from deep down.

23. When did they reassemble and where ?

The Maoris reassembled right away after the fight. Te Huia and his father and relations met together beyond the *puinu* and at Otewa.

24. Did he ever fight again ?

He did not fight any more. Some time afterwards, whilst with Rewi, they nearly fired upon some soldiers, but they had a sooth-sayer, a *tohunga*, or priest, with them, and he prophesied that they would have bad luck if they fired a shot, so they turned back.

Asked later why Orakau had been selected for the site for the battle when there was a better position on higher ground on the Kariponia ridge, Te Huia replied that the *pah* was built, so as to block the road along which the *Pakehas* would always come, so the Maoris thought best to stay and wait for them there.

He said they had a field-glass, which was not as much benefit to them in the *pah*, but when they were able to get to the top of a hill, they could see all over Kihikihi and other places.

He said that one Maori, his eldest brother, was taken prisoner, and his gun was taken from him, and whilst being escorted to the rear by two soldiers, they were stopped by twelve troopers, who insisted on taking him in charge so that they could shoot him. They made a ring round him and armed him with a *taiaha*, an ancient Maori weapon, and made him fight one of them. He killed two soldiers and then sprang over the top of the others. One struck him with the butt of a rifle in the knee, and many of their bullets grazed him. One hit him in the shoulder and the blow on his leg so lamed him that he ran practically on one leg. Eventually, he completely recovered.

A question was raised as to what the Maoris thought of Rewi as a general. They said that he was a very high man amongst them. He was related to practically all of the tribe (a very well-bred man), and they looked up to him as a man of good blood. He was a brave man and very kind to children and grown-ups alike, and they looked up to him with respect.

Te Huia said that both the beautiful girls were killed. One was wounded and died at Orakau, and the other was wounded and taken a prisoner to Te Awamutu, where she died.

The great battle was fought in March and the weather was beautiful and the *pah* quite dry. It was only a small *pah* in those days. He said they enjoyed fighting, but they did not fight for a joke, as they were very wild with the *Pakeha* and were in earnest.

Rewi and his relations went back to Kihikihi. He often moved amongst the soldiers. Indeed, after the soldiers moved up to Te Awamutu, Rewi and his companions from Paterangi just walked through the place, and the soldiers let them pass, not knowing that

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the great chief Rewi was amongst them. Rewi was, however, above all things, fair in his dealings and hated anything underhand.

Asked if the Maoris had thought they could beat the soldiers at Orakau, Te Huia replied they were all strong men and had they not thought so, they would not have been there.

Te Huia stated that one of the older men did not retreat from the *pah*, but stayed with the wounded, holding up a white handkerchief upon a stick, and when the soldiers rushed with their bayonets, they did not hurt him, but took him prisoner.

He attributed their escape from total destruction when they charged out of the *pah*, to the fact that they rushed between two lines of soldiers, who could not fire for fear of hitting each other.

The old man made a dignified figure, and it was most impressive to see him demonstrate the loading and use of the old muzzle-loader, the biting off the bullet from the cartridge, the pouring the powder down the barrel with the bullet on top of it, and bumping the butt on the ground, so as to settle the charge, and as he related each incident, to see him point to the place with his stick where it actually took place.

Everyone was most interested and showed great consideration for his age and standing. Many lingered, asking questions after the official recital was over, and many further questions were asked, but where he had not witnessed an incident he said, " I do not know that, I did not see." He gave no hearsay anecdotes. His quiet bearing and gentle manner, together with his wonderfully alert mind and physical activity, caused considerable surprise to those who had never met an old-time Maori warrior. Such a gathering in such a place, combined with so interesting a personage, must have been almost unique.

CORRECTIONS.

R.E. Journal, December, 1929, page 538, " Mining in 1915," lines 10 and 11, read, " the mining was carried out by Lt.-Col. D. M. Griffith, D.S.O., under the direction of the C.R.E. of the Division, now Brig.-Gen. J. A. S. Tulloch, C.B., C.M.G."

Page 608, " Afghan Wars," for " Nuttall " throughout this page and at top of page 609, read " Burrows."

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MEMOIRS.

BRIGADIER-GENERAL EDWARD ROWLAND BENNETT STOKES-ROBERTS, C.B.

FOREWORD.

BRIGADIER-GENERAL STOKES-ROBERTS died in Mesopotamia on November 22nd, 1917, when holding the appointment of Director of Works, M.E.F. The general conditions precluded the publication of a memoir in the *R.E. Journal* at the time of his death, and, as a scholarship has been founded at Chatham as a memorial, the following memoir is now published.

EDWARD ROWLAND BENNETT STOKES-ROBERTS was born on July 10th, 1865, the only son of Edward Stokes-Roberts, who died while the subject of this memoir was still a child. He was adopted by his grandmother and educated first at Mostyn House, Cheshire, and then at Clifton College. From there he passed direct into the Shop. He obtained his first commission in the Corps in December, 1884, and sailed for India in January, 1887.

He saw active service almost at once, as he served with the Upper Burmah F.F., under Sir Robert Low, as Assistant Field Engineer, and received the medal and two clasps. He then served at Roorkee with the Bengal Sappers and Miners for a year, proceeding with the 3rd Company on the Hazara Campaign of 1888. For this, he received a clasp. He reverted to the Home Establishment in 1893, and was engaged on the work at the Cordite Factory, Waltham Abbey, from 1895 to 1900.

As a result of his work and experience there, he was offered on his return to India at the end of 1900, the job of constructing the Cordite Factory at Aravankadu, near Wellington. This was a big job, and comprised, besides the actual factory, the construction of quarters for officers and subordinates, and the Khateri Dam and power house. He had studied the question of reinforced concrete, which was then coming to the fore, whilst employed at Waltham, and he was able to make use of this knowledge at Aravankadu. He may be regarded as the pioneer of the use of reinforced concrete and of reinforced brickwork in India, and he wrote a brochure on the subject, which was thus first introduced to the M.W.S. This publication also con-

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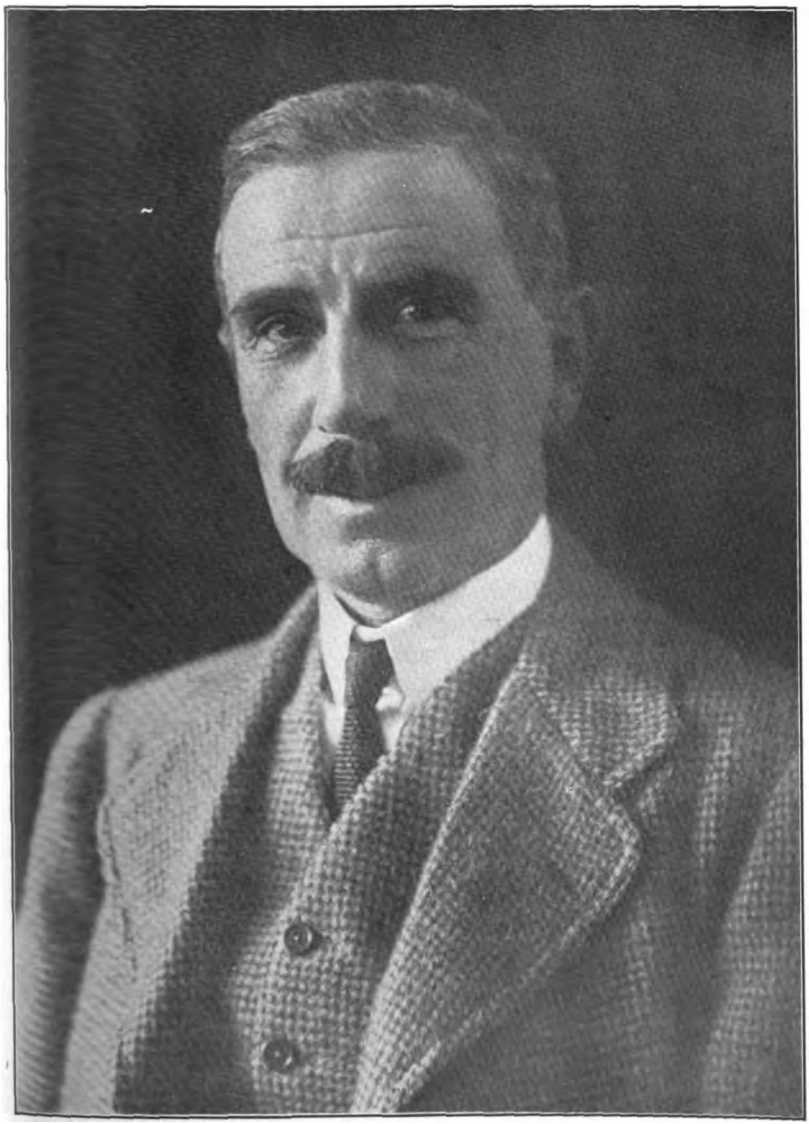

Brig.-General E. R. B. Stokes-Roberts.

Photograph by Olive Edis.

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tained particulars of the cylindrical reinforced brickwork water tanks, first devised by himself, a design which has proved most useful and economical.

After attending the " Wild East " course at Chatham, he was, on return to India, in 1904, put in charge of the work at Jabalpur, under the Kitchener Reorganization Scheme.

Of this period of his career, Brigadier W. H. Evans writes as follows :—

" I made Stokes-Roberts' acquaintance at Jabalpur, in the winter of 1904–5. After completing the Cordite Factory at Aravankadu, in the Nilgiris, he had been home on leave, and on his return was appointed A.C.R.E. Reorganization, Jabalpur, a new appointment in connection with the large building programme attendant upon Kitchener's reorganization for India. I was lucky enough to be one of his garrison Engineers throughout the work, which was completed in 1908.

" We had a big job at Jabalpur : the remodelling of the old cantonment and the addition thereto of several units, and also the construction of a new cantonment on the ' Ridge,' five miles away, for a whole British infantry battalion and a large hospital, with all the attendant roads, water supply, etc.

" Stokes-Roberts was a brilliant engineer in three directions ; power of organization, sound knowledge of detail and the patience to attend thereto, and the gift of being able to impart his knowledge to others. He was always out for new ideas, searching for them himself, and encouraging us all to search. He always gave us full credit for anything we did. He introduced into India the art of moulded reinforced concrete, whereby at Jabalpur he saved the State a very large sum of money. The cantilever stable-truss and the reinforced brickwork water tank were his own inventions, both of them novel, sound and economical. During his stay at Jabalpur, he wrote a book entitled, *Some Practical Points in the Design and Construction of Military Buildings in India*, embodying many of his methods, the study of which would repay any engineer to this day.

" What one becomes in after life is dependent to a very great extent upon the tutors of one's youth, and Stokes-Roberts succeeded in converting me from an unlicked subaltern into a comparatively useful officer. He lived for his work and impressed his keenness on others. We all loved him and I, for one, can never be too grateful for all he taught me. His service was wholly unselfish ; there was never any thought of gain or self-advertisement, just loyalty to the Government he served, and just and generous treatment for those who served under him."

After these many strenuous years of hard work on original construction, Stokes-Roberts had a breather at Bareilly, where there was but little new work in hand.

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Here there was leisure and opportunity for small game shooting in one of the pleasantest stations in India, a sport of which Stokes-Roberts was always fond, as well as of big game shooting. He was also a first-rate fisherman and an authority on the fauna of India.

Bareilly was followed by the very heavy routine work at Rawalpindi, and then at Mhow. By this time, the Great War had been going for some months, and Stokes-Roberts, like most of the officers serving in the M.W.S., had been retained in India by the Authorities as a reserve for possible eventualities in that country.

The force which was eventually known as the Mesopotamia Expeditionary Force had left India in October, 1914, and after a victorious career of a year, met its first check in its attempt to capture Baghdad. As a result, the force under Gen. Townshend was besieged in Kut, from December 3rd, 1915, till it surrendered to the Turks in April, 1916. The Tigris Corps, M.E.F., was formed for the relief of Kut, and on January 31st, 1916, Stokes-Roberts joined as Chief Engineer. He held the post for three months only, and was then appointed Director of Works, M.E.F. The difficulties for an engineer in this country were immense. The only tree the country produces is the date palm, and there is no stone. Everything in an engineering line had to be imported from India and England, and, to begin with, facilities at Basra for the landing of stores simply did not exist. Practically everything had to be started from first principles, and those who remember the peculiar stickiness of the Mespot mud and the depth to which it was possible to sink will realize that the first desideratum at the Base was some sort of metalled road, not a single specimen of which existed in that part of the country. Stone being unprocurable, it was circumstantially reported in India, at the time, that the road out to Makina Masus was made of neat cement! The eventual conjuring of order out of chaos, and of victory out of defeat, is a story of the War that is well known; and no small measure of the responsibility for this success lies in the work of Stokes-Roberts. Lt.-Gen. Sir George MacMunn, who was Inspector General of Communications of the Force at the time, and under whom Stokes-Roberts worked, has kindly contributed the following appreciation:—

"My acquaintance with General Stokes-Roberts dates from my arrival in Mesopotamia in April, '16, ten days before the fall of Kut, to take over the duties of Inspector General of Communications. Stokes-Roberts had just been appointed Director of Works to the Force. When he came to see me, he was suffering considerably from disappointment that he had been transferred from his post at the front, where he had undergone severe strain. I found him quite the most zealous, efficient and able engineer it has ever been my privilege to meet, and also the most lovable and admirable of men.

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"I think I was able to cheer him up and make him feel he would have the power to deliver the goods, by promising him as much authority and initiative as he could use and explaining to him the immense work we had before us, the unlimited authority the Commander-in-Chief had given to me, and the promise I had had from the Quartermaster-Generals at the War Office and Simla of the fullest support. I also guaranteed to relieve him of all control from the Engineer-in-Chief, who, under the *F.S. Regulations*, was not concerned with the L. of C., and that he should take his orders and approvals direct from me, verbally and promptly, and from me alone, and that once he had them, he was to be untrammelled.

"Stokes-Roberts then took charge in the most magnificent way of the vast plans necessary to bring the base and L. of C. from a scale of two divisions badly found to that of ten divisions well found, working five hundred miles from their base; roads, hospitals, water, electric light, ice, many of the piers and wharves, etc. His initial difficulties in the way of shortage of officers, sickness, and the dearth of works companies, labour corps, artificers, material, etc., were immense. These difficulties, as well as the work of ensuring that the base park complied with all the demands of the Engineer-in-Chief, were brilliantly tackled.

"He came to me constantly, to tell me of his needs, plans, and devices, and I have the most vivid sense of gratitude for all he did to help me make it possible for Sir Stanley Maude to take Baghdad, and for the troops, fit or sick, to be treated as troops who must win should be treated.

"No mere recitation of tasks can give an adequate presentation of all that Stokes-Roberts and his officers went through, especially in that hot season of 1916, when depression after the fall of Kut was rife and the hospitals crowded, without accommodation, water, lighting or ice. His appointment as Brigadier-General helped him considerably, and when Baghdad fell, and his endeavours were rewarded with the Bath, he felt, I think, that life was worth living. To none of the workers, who made that line of communications on the two rivers and that base out of a mud-pie, is the success of the campaign due more than to Stokes-Roberts, and it was to the intense grief of all that, with his frame weakened by climate and super-exertion, he could not stand up against an attack of pneumonia, and followed his great Commander-in-Chief to the grave.

"Surely of him may it be said, with the prophet Malachi: 'And they shall be mine, said the Lord of Hosts, in that day when I make up my jewels.'

"With Stokes-Roberts was Edgar, as his number two, a man also of immense energy and devotion whose premature death in his prime, a year or so ago, was undoubtedly due to the strain of those years on the Tigris."

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Stokes-Roberts died at Baghdad on November 22nd, 1917, and the following year a movement was set on foot amongst the Works Directorate personnel, largely consisting of Indians, to raise funds to commemorate him. With the amount subscribed, a memorial was erected at Baghdad, a portrait was painted for the Chatham Mess, where it now hangs, and with the balance, an annual prize was instituted, "to be known as the Stokes-Roberts Scholarship, and to be competed for by N.C.O.s undergoing a construction course at the S.M.E., under conditions laid down from time to time by the Commandant, S.M.E. Preference to be given to those, if any, training for the M.W.S. in India."

In 1886, while still a young officer on the S.M.E. Establishment, Stokes-Roberts married Frances Edith Helps, daughter of Mr. Helps, of Upton Lawn, near Chester, by whom he had two sons and two daughters, the eldest son dying in early infancy. His surviving son is now Brevet-Major A. E. Stokes-Roberts, O.B.E., M.C., *p.s.c.*, The Worcestershire Regiment.

P.H.K.

COLONEL RALPH PUDSAY LITTLEDALE.

COLONEL RALPH PUDSAY LITTLEDALE was the third son of Henry Anthony Littledale, Esq., of Bolton Hall, Clitheroe.

Born on 17th February, 1856, he was educated at Marlborough College, and passed into the R.M. Academy, Woolwich, in November, 1873, passing out sixth in a batch of seven R.E. on 19th February, 1876.

After the full course of two and a half years at the School of Military Engineering, the whole batch was antedated six months to 19th August, 1875.

Littledale was selected for service at Aldershot, where he joined the 17th Field Company.

On January 22nd, 1879, occurred the disaster at Isandlwhana, in the Zulu War, and among the troops dispatched as reinforcements was the 30th Company, R.E.

Littledale was selected as the junior subaltern, the other officers being Major and Bt. Lt.-Col. (now Sir Richard) Harrison, Capt. (now Sir Bindon) Blood, with Lieuts. F. W. Watkins, K. McKean and C. W. Sherrard. The 30th Company, after a trying voyage, reached Durban in April, 1879.

Of this episode General Sir Bindon Blood writes as follows: "I recollect how well Littledale stuck to it during the voyage, some of which was rough; staying down below with the horses in all weathers. We did not lose one of the horses during the voyage, which was very trying for them. Directly we landed at Durban,

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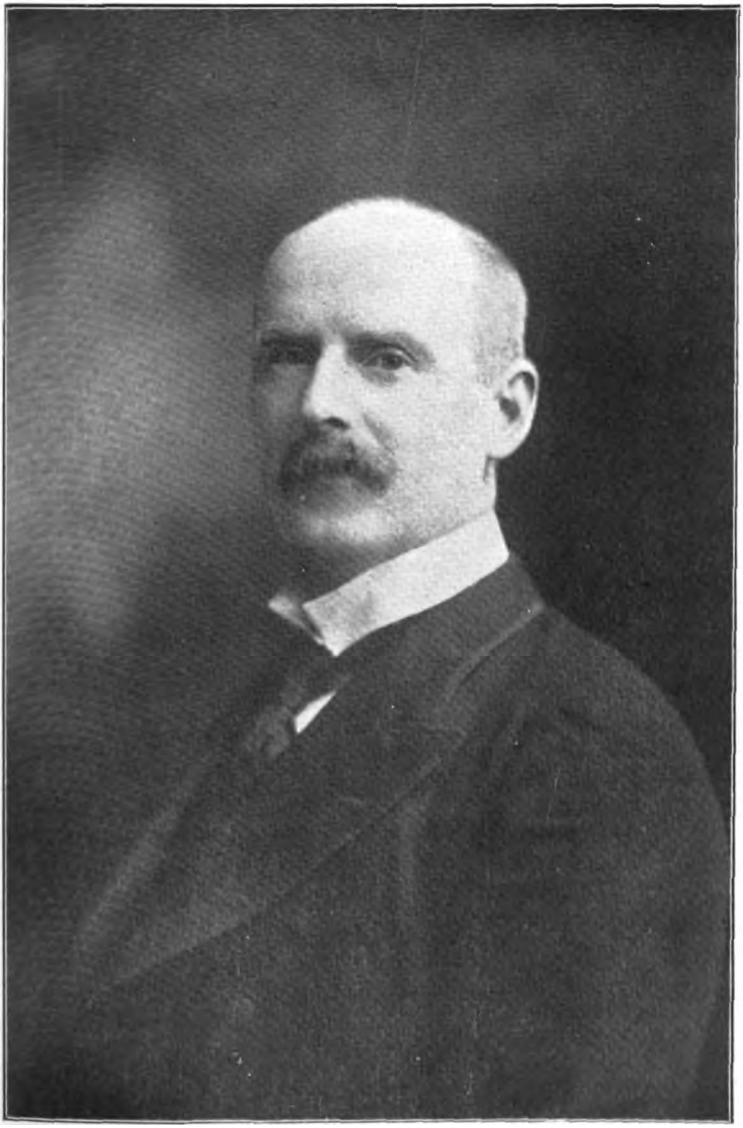

Colonel Ralph Pudsay Littledale.

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Col. Harrison and I were taken away from the Company—he as A.Q.M.G. of one Division (the 2nd), and I to be C.R.E. of another (the 1st). The Company was attached to my Division and was broken up into sections under the subalterns, for most of the Campaign doing a great deal of good work, especially in bridging the Tugela and other rivers, in road-making, entrenching, etc. Littledale had his full share of work throughout, and I remember that he did right well."

The Zululand Campaign was brought to an end by the battle of Ulandi, fought by the 2nd Division and the Mounted Troops, under the Command of Lord Chelmsford, on 4th July, 1879.

The 30th Company was ordered to Gibraltar in November, but Littledale was retained in South Africa for duty on a boundary commission, which had the task of defining the boundary between Zululand and Swaziland. The boundary selected was adopted, and on 15th April, 1880, the Commission received the thanks of the Commander-in-Chief, Sir Garnet Wolseley.

Littledale was then posted to the 2nd Field Company at Pretoria, and on the outbreak of the Boer War of 1881, was besieged in Pretoria with this Company until the end of the Campaign. He was mentioned in dispatches and received the thanks of Field-Marshal the Commander-in-Chief.

He was ordered home the following year, and in January, 1883, joined the 7th Field Company at Aldershot.

In September, 1884, on the dispatch of the force to Egypt to relieve Gordon, Littledale was selected to command the Field Park and embarked in the S.S. *Rewa*, in company with a number of other R.E. officers. He seems to have established a reputation by this time of taking very good care of his men.

His first station was Wady Halfa, and he moved up the Nile as the Campaign required, but the R.E. work (except the railways and telegraphs) was not important, mainly from the lack of transport facilities. He returned to Aldershot in September, 1885, and later went through the full course of musketry at Hythe, and also the veterinary course. Promoted Captain in 1886, under the eleven years' rule, he was, in October, 1887, ordered to Mauritius to take charge of special loan work at that station.

Up to this time his work had been mainly of a military nature, including three campaigns, and it is interesting to note how, when transferred to constructional work, he developed into a first-class constructional engineer. The result is a fine testimony, not only to his own sterling qualities, but to the efficiency of his early training at the Royal Military Academy and at the School of Military Engineering.

In 1887, there was in progress, at Mauritius, work under a barrack loan for which the money was provided by the Home Government,

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and work under a fortification loan, with funds provided mainly by the various Colonies concerned.

Mauritius was then, and still is, a hotbed of malaria, and all the troops and individual officers, except a small garrison of R.A. and R.E. in the principal fort on the sea-front, lived up-country. Finding the work on one of the batteries going slowly, Littledale went down and lived on the site. He got the work done, but paid for it with a bad attack of malaria, which left an after-effect of deafness, from which he suffered in later years.

Two of the four new forts were constructed under his supervision, and he was also responsible for commencing the new brick barracks at Curepipe. During his tour in the island he developed in a marked degree the capacity for getting work done, especially when working with native contractors and an inadequate staff.

Ordered to England at the end of 1890, he was employed as Assistant Adjutant for Musketry at the S.M.E. during 1891.

In April, 1891, he married, and in December he was appointed Adjutant of the 1st Cheshire Volunteers R.E., with Headquarters at Birkenhead. The efficiency of the Volunteers at that date was much below the present Territorial standard and Littledale found a good deal which required improvement and alteration. The work was arduous and not very congenial; but his high sense of duty forbade any withdrawal on his part, and he stuck at his job for the full five-year term of his appointment, at the end of which he was rewarded by handing over to his successor a really efficient unit.

He was promoted to Major on 1st March, 1895, and in January, 1897, went to Glasgow as Division Officer, and was there till, in July, 1900, he was ordered to Hong Kong for special duty in charge of loan works at that station.

The engineer work at Hong Kong was then under a Colonel who was called District Engineer, and under him the officer in charge of loan work was in the position of a C.R.E., and had his own staff of Division officers and surveyors.

The work was important, as in 1898 we had taken over from the Chinese, on a ninety-nine years' lease, a large extent of new territory on the mainland, together with 600 islands of all sorts and sizes. This addition for the first time gave us control of the north shore of Hong Kong Harbour, and allowed of the fortification of the north side of the Eastern Entrance, known as the Lyemun Pass. In addition to this, all the defences at both entrances were remodelled and re-armed, and additional 6-in. and 12-pdr. Q.F. guns fitted with automatic sights were installed. There was at the same time a considerable addition being made to the Garrison, involving a good deal of barrack construction with married quarters, and the provision of a new hospital of 180 beds. Also, it was decided to push out the local land defences, which, up to then, had been limited to a local

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defence of forts and barracks, and to occupy the crest of the hills which run from east to west across the island of Hong Kong and on the mainland.

Littledale, in the course of two years, completed nearly all the fortification work, most of the work in the barracks for European troops, and started the hospital at Bowen Road.

Special mention must also be made of the system of hill roads on Hong Kong which he laid out personally, and which were afterwards taken over by the Civil Government.

As the Senior Officer of the R.E., he acted as District Engineer when the latter officer was away on leave, and always enjoyed the full confidence of the G.O.C. and D.E., and I may add of the War Office, which accepted practically all his proposals. His work was again characterized by his capacity of getting work out of the local Chinese contractors, with whom he was on very friendly terms.

He was promoted to Lieutenant-Colonel in January, 1902, and was ordered to Malta to complete his tour of foreign service as C.R.E. of the West Sub-District. Here his principal work was the completion of St. Andrew's Barracks. The work was not quite so congenial to him, as he was executing schemes prepared by his predecessors, but he carried it through with his usual energy to the satisfaction of the local officers and of the War Office.

In 1904, he was ordered home to Dover as C.R.E. of the Dover Sub-District.

In April, 1905, following the changes introduced by the Esher Committee, the District Engineer at Dover and the C.R.E. at Shorncliffe were abolished, and Littledale found himself responsible for the whole of the work formerly done by these officers. About the same time, the District was transferred from the Southern Command to the Eastern Command, which had its Headquarters in London. All this threw a great strain on the C.R.E., but Littledale proved equal to the occasion, and his sound advice and the thorough way in which he dealt with every question which came before him, were much appreciated by the General at Dover, and the Chief Engineer at Command Headquarters.

In January, 1906, he was promoted Colonel in the army.

In January, 1907, he completed five years' service as a Lieutenant-Colonel R.E. He was not well-placed for further employment, as the number of Colonels' appointments had been much reduced, and there were many officers already waiting for vacancies. He, therefore, elected to retire and devoted himself to his favourite hobby of archæology, combined with gardening and carpentry.

In 1914, when the war with Germany started, he at once volunteered and was posted to his old job as C.R.E., Dover Sub-District. The work was too much for one man, even of Littledale's

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capacity, and, in January, 1915, a new C.R.E. was appointed to Brighton, who took over the County of Sussex. This still left in his charge the greater part of Kent, including the Fortress of Dover, and the work was increased by a decision of the War Office, in May 1915, to make Shorncliffe the headquarters of the Canadians in England. Their number eventually reached 60,000 men, involving a great deal of work for huts, camps and billets. There were also quartered in his District two or three Divisions of the Central Force in billets and camps, who made continual calls for his services.

Later, as the importance of the Dover Fortress increased, it was found necessary to appoint a separate C.R.E. for the Fortress, and Littledale then moved his office to Ashford, where he remained till September, 1918, when he was relieved by a serving officer.

An officer, who was serving at Shorncliffe, writes of this period: " In my opinion, Littledale's work was magnificent. He seemed to be everywhere, and how he managed to get about as he did, I could not make out. There seemed to be no delay in beginning and carrying to completion any agreed work."

Littledale's name was included among the officers who received the thanks of the Secretary of State for War in *The London Gazette*, of 24th February, 1917.

After his second and final retirement, he resumed his research and literary labours, spending hours at the Record Office in Chancery Lane. Among other work he completed three volumes for the Cumberland Archæological Society. He also compiled the record of his own family back to the fourteenth century, a monumental work which took him ten years of research.

Littledale had the reputation, while in the army, of being quarrelsome and argumentative, but this was only one side of a complex character. He dearly loved an argument, and, when in the course of his military work his opinion differed from that held by another officer, he was apt to press his own view rather to extremes. But with him such disagreements never rankled and the stormy period was soon over.

But this defect, which undoubtedly affected his own prospects, should not be allowed to hide his many excellent qualities. He was a very quick and accurate thinker, getting to the root of a question and working it out to its logical conclusion. As one senior officer put it, " when Littledale had finished a report on any subject referred to him, there was very little left for anyone else to write about."

Capable of taking infinite pains, and ready to go into details if necessary, he never allowed the consideration of details to obscure his main object. Also, he always looked well ahead of the immediate present, so that when work was once started, it went on as if by clockwork, and there were no irritating delays.

He was a very hard worker, working long hours himself and

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requiring the same from his subordinates. To his juniors he must sometimes have appeared to be a hard master, but once accustomed to his methods, all his subordinates and staff liked and trusted him.

One of his Division officers, when he was C.R.E., Dover, writes as follows: "To serve under him as a D.O., was an education. When issuing his instruction on some question referred to him, he would sum up in a sentence some general principle on which the instruction was based, showing how similar cases should be dealt with in the future."

The same officer, a few years later, was given the duty of editing the 1910 edition of *R.E. Services*, and he adds: "Section I. General Principles, in the *Regulations for Engineer Services*, 1910, was an amplification of a collection of Colonel Littledale's *obiter dicta* on matters referred to him as a C.R.E." A fitting memorial of his military work.

Littledale was of more than average height and of late years put on weight, and those who did not know him well can have no idea of the real kindness of heart and unselfishness which lay behind that rather terrifying exterior. His friends found him a most charming companion, always ready to do a kindness or to help a lame dog over a stile. He probably never did a selfish thing in his life, and pushed his self-abnegation so far that he would never apply for any appointment or employment for himself. Socially, he was popular with everybody, a good shot and rider, and able to hold his own at games. But he showed his best qualities as a host in his own house, or presiding at a Guest Night at Mess. He liked nothing better than to get a few intimate friends to dinner, when he would sit on after dinner till the small hours, talking on every subject under the sun, except his work, and keeping us all interested with his conversation and anecdotes.

His end was characteristic of the man. In the bitter winter at the beginning of 1929, his own house was happily free of frozen pipes. But hearing that his neighbour, a widow and an invalid, was unable to get hot water, he went to her help, scraping snow and ice from her gutters and carrying large cans of hot water up and down steps, through the gardens and into his neighbour's house. The strain was too much for him, and after a bad night he passed away suddenly the next morning from the failure of one of the main arteries.

His wife, who survives him, was the daughter of Lt.-Col. C. L. Tredcroft, *J.P.* (late R.H.A.), of Glen Ancrum, Guildford. They had two children. His only son was killed at Cambrai in 1917, at the age of 22, while serving as a Captain in the 5th Northants Regt. His daughter, who is an M.A. of Cambridge, has inherited some of her father's literary tastes, and held for some years the post of an assistant librarian at the Bodleian Library, Oxford.

W.B.B.

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PROFESSIONAL NOTE.

DRYING OUT NEWLY-BUILT DWELLING HOUSES BY HOT BLAST. ("TUBIT" METHOD.)

MESSRS. SCAFFOLDING (GREAT BRITAIN), LTD., of 43, Lansdowne Road, S.W.8., are carrying out an experiment in quick drying of newly-built and plastered houses, to enable habitation to follow completion immediately, without the danger to health which may ensue and cause rheumatism and the allied heart trouble. These diseases are to-day the most vital causes of inefficiency in the nation, and as such, are being enquired into by the National Medical Council.

The invention is a German one and Messrs. Scaffolding have acquired the rights for the United Kingdom. They are now carrying out their first experiment in their own newly-built offices at Stockwell, S.W.8.

The method used is to pass air over burning coke in an oven and force it through 20-in. pipes into the building under a certain amount of pressure. The portion of the building to be treated is previously closed externally, though all interior communications are left wide open: all external windows and flues are closed and external doors are covered with stout brown paper inside so as to assist in preventing leakage. It is claimed that the hot mixture of gases which is pumped in by the electric fan is forced through the fabric of the walls and roof and floors, drying them thoroughly during the process. The external surface of the walls of the space under treatment felt hot to the touch.

The apparatus consists of a coke boiler on wheels, about 5 ft. x 3 ft. in horizontal section, fitted with controlling louver and an electric fan to drive the products of combustion along the tubes into the building.

These gases are delivered normally at a temperature of about 150°F.; the thermometer at the far end of the flat, which was inspected, stood at 120°F. The heat, however, is regulated at the furnace and the pressure is more or less regulated by the fan. Apparently, the technique of the work is to begin with the hot gases at about 75° for the first six hours, and then gradually raise it to the normal till the drying is accomplished, and then to take about six hours to cool off gradually. After that the tubes are withdrawn

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and the doors, windows and other openings kept shut till the next day. The blast treatment takes from 48 to 72 hours. To avoid warping, as little woodwork as possible is allowed in the space to be dried; wooden floors, doors, architraves, mouldings, sills, are put in afterwards, though door frames and windows may be necessary.

The foreman informed me that he spent about half an hour at a time in the space under treatment, every three hours, to regulate the temperature and examine the state of the walls, etc. The hot gases contain enough sulphur fumes to be unpleasant: they cause the eyes to water and a choking sensation in the lungs, which wears off in a few minutes; also a slight feeling of vertigo which the foreman no longer experienced. The writer felt no noticeable after-effects.

The director, who was interviewed afterwards, maintained stoutly that there was no fear of the presence of carbon monoxide, as was proved by continued analysis. He held that the large amount of carbon dioxide passing through the material of the walls, tended chemically to harden the set of the plaster rendering and also the cement or lime mortars in the wall.

Efflorescence was present in large quantities both on the surface of the internal plastered walls and also of the external brick walls. The director averred that such efflorescence came out very quickly, and when once brushed off, would never appear again, as the impurities causing it combined with the penetrating gases and were carried away once for all.

The approximate price of the application at present varies from 10s. per 1,000 cu. ft. of space to be treated for 250,000 cu. ft. or more, to 35s. per 1,000 cu. ft. for 40,000 cu. ft. or less. One furnace will supply enough hot blast to treat about 27,000 cu. ft. of space.

The director said that the method had been in use all over Central Europe for some years and they had dealt with factory buildings of over 400,000 cu. metres in content. Also that in some German municipalities, habitation of newly-built dwelling houses immediately after completion was forbidden except when dried out by Tubit.

The assertion that the damp, once driven from the walls of a building by the Tubit method, can never return has yet to be proved when subject to our humid atmospheric conditions. It is hoped to make a further investigation in a year's time.

D.M.F.H.

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BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

THE BIOGRAPHY OF THE LATE MARSHAL FOCH.

By MAJ.-GENERAL SIR GEORGE ASTON, K.C.B. (Hutchinson & Co., London. 1929. Price 24s.)

The biography of Marshal Foch has still to be written. In this volume Sir George Aston has provided a great deal of useful material for it, but it is by no means the whole history of his life. He has done a great service by recording for the use of future generations of soldiers the foundations on which the character of the great French Marshal, who led the allied armies to victory in 1918, was based; and in the latter half of the book he has put together a great deal of useful information of the personal part played by the Marshal in the Great War, particularly in relation to the British Army. That Foch was a man of great character is an established fact. "The key," writes Sir George, "to that character is to be found, undoubtedly, in a sincere faith in "an Almighty Providence caring for the destinies of mankind, and "this is best illustrated by the following story, in which this faith is "indicated though not publicly expressed: At the time, in April, 1918, "when the powers of Foch to co-ordinate the Allied effort developed "into the nominal command of the Allied armies, he said, 'Materially, "I do not see that victory is possible. Morally, I am certain that we "shall gain it.'"

Ferdinand Foch was born at Tarbes, in 1851, the year before Napoleon III. was placed on the throne of France. He came of good, middle-class stock. On his father's side there had been no soldiers: his forbears had been engaged for several generations in the wool trade with Spain. But his grandfather was a fervid admirer of Napoleon Bonaparte and named his son after him. As a child, Ferdinand often spent his holidays with him at Valentine, at the foot of the Pyrenees, and he was, no doubt, much influenced by him. On the other side, there was a more soldierly strain, and Ferdinand's interest in military matters was fostered by the military traditions of his mother's family. His maternal grandfather who had served under Napoleon made his home with the Foch family. From both his parents, Ferdinand Foch inherited his sense of duty, his deep religious instincts, and the loyalty and painstaking persistence of purpose which characterized him throughout his career. Tarbes was a horse-breeding centre, and there was good fishing

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and shooting in the neighbourhood. There the boy learnt to ride and fish and shoot. At the same time he was of a studious turn of mind, and soon became fond of reading and passionately fond of reading books of fighting and adventure, particularly books about the Great Emperor and his relations with France. The Napoleonic tradition was very much in the air at this period, and Ferdinand was reared in an atmosphere of Napoleon worship. Before he was twelve he knew every one of the Emperor's campaigns by heart.

One day, when searching for him to join the family in an expedition, his father found him sitting on the library floor surrounded by books dealing with Napoleon. "What are you doing?" inquired his father. Young Foch looked up with a harassed frown. "I want to find out what Napoleon did in his school holidays," he replied, "but I cannot find out whether he went fishing. I should enjoy it so much more if he did."

He was sent to a Jesuit school as a day boy. The Jesuit schools had a great reputation for preparing boys for the army. It was not until he was eighteen that he first left home, to go as a boarder to the Jesuit College of Saint Clément at Metz, which had a great name for preparing youths for the great military colleges at St. Cyr and the Ecole Polytechnique. It was a cosmopolitan gathering, the students coming from all parts of the world, and Foch gained much useful experience from intercourse with them and an insight into various types of character that served him well in later days. He was clever, very hard-working, and had a decided turn for mathematics; his conduct was irreproachable from the points of view both of the teachers and his fellow students, and he was popular with all. While at Metz the Franco-German War broke out in July, 1870. He immediately left to join up as a recruit in the infantry, but to his bitter disappointment never got to the front. After the armistice in January, 1871, he returned to Metz for a few weeks and resumed his studies. His best school friend had been killed fighting. On hearing of his death he is said to have muttered: "A great death, and one to be envied. You shall be avenged." He kept his vow. From that moment *La Revanche* was his life motive.

To quote the author:—"With some strange foresight of what was "to come, Foch seems to have made a special study of German psycho-"logy. (Metz was then occupied by the Germans.) He often mentioned "to his companions that he had noticed certain attributes of the Germans "which, in his opinion, should never be forgotten in any dealings with "them, and throughout his life he retained the impression which he "then formed of the German temperament. He seemed to realize, in "some strange way, that the conflict in which his destiny was to be "so deeply involved would be renewed at some future period. Not "long before he passed away he said to a friend, 'I merely strove to "apply the conclusions of an essay which had been given us to work "upon at Saint Clément, when the country was being invaded by the "Germans whom I meant some day to pursue.'

* * * * * *

"In some inexplicable way his consciousness of future greatness "communicated itself to others. One of the professors, who knew Foch

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" merely as one among his large class of young men, looked intently " at him one day, noted his eyes and his forehead, and remarked to a " colleague, ' That young man will accomplish later something immense.' " And so with others. There was nothing outstanding about his " physical appearance to cause this strange faith in his future. It " must have been a realization of his character, his great steadfastness, " great tenacity of purpose, determination and the power shown by the " expression of his face that caused his friends to foretell a great future " for the young man."

About this time his younger brother became a Jesuit priest. " We shall both serve France," Ferdinand said to him. " You to pray for her, I to fight for her: who knows which is the better service? "

When Metz was handed over to Germany, Foch, now twenty years of age, proceeded to the Ecole Polytechnique at Paris. He has recorded the fact that there he " learnt how to learn." Then, after a course at the Ecole d'Application at Fontainebleau, he became a 2nd-Lieutenant in the Field Artillery, on February 10th, 1872.

After four years' regimental soldiering, he entered the Cavalry School at Saumur. His early experience at Tarbes helped him to develop into a first-class horseman with good hands and a good seat, but the strenuous training at the School was probably the cause of the illness to which he eventually succumbed. The next seven years were mostly spent at the Ecole Supérieure de Guerre—the French Staff College—first as a student, then as an instructor, and eventually as Chief Instructor.

The chapters describing the various phases of Foch's military education are extremely interesting, because the author goes into a considerable amount of detail to explain the use and purpose of the various military training centres and discusses the Ecole Supérieure de Guerre at some length. The information he gives would be most useful to any British officer attached to the French Army. Speaking of the Ecole Supérieure de Guerre, Sir George Aston writes :—" The Ecole Supérieure de Guerre " at that time had men of distinguished mental ' gifts ' (Foch never " believed in gifts) and brilliant lecturers, but amongst them all, Foch " stood out in the opinion of the officers under instruction as the most " original thinker and the most profound student. They all listened " with avidity to his lectures and they all felt that by his influence their " minds had been stimulated." Some of us will be reminded by these words of the wonderful influence of Colonel Henderson (of Stonewall Jackson fame) on the Staff College students before the South African War.

The chapter on Foch's " Rise to Reputation " is full of interest to Staff College officers of the present day, as indeed is the whole volume, the remainder of which deals with the personal part played by Marshal Foch in the Great War, and after the Armistice, with special reference to his relations with Earl Haig and the British Army. Except for a certain amount of repetition and overlapping of chapters, due, perhaps, to the limited time given to the author in which to produce the book, it is a very readable account, and will form an invaluable adjunct to the British *Official History of the Great War*.

H.B.-W.

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THE DECISIVE WARS OF HISTORY.

A Study in Strategy.

By Captain B. H. Liddell Hart.

(G. Bell & Sons, Ltd. Price 12s. 6d.)

In this interesting book the author claims to have discovered what it is that ensures a decisive result in war. This is the employment of the "strategy of indirect approach" which in all decisive campaigns has led to the "dislocation of the enemy's psychological and physical balance which has been the vital prelude to a successful attempt at his overthrow."

Captain Liddell Hart has had the advantage, as military editor of the new *Encyclopaedia Britannica*, of being able to survey the whole field of military experience. In this book he gives us the result of his study. He gives us, in Part I, short accounts of many wars, ancient and modern, from the Persian War of B.C. 490 to the Russo-Japanese War of A.D. 1904; in all, twenty-seven wars embracing more than 240 campaigns. In each case he considers how far the directness or indirectness of the approach affected the issue. In a chapter devoted to conclusions he draws deductions which seem to show some confusion of thought. If the object of the author is to prove the value of the strategy of indirect approach, surely he is mistaken in saying that the lessons can be crystalized into the following two simple maxims. Firstly, that no general is justified in launching his troops to a direct attack upon an enemy in position; secondly, that instead of seeking to upset the enemy's equilibrium by one's attack, it must be upset before the real attack is, or can be, successfully launched. The second maxim can be read strategically: the first is tactical. Even in adapting a saying of Lenin's to point his moral he spoils it by introducing an application of tactics. This is the more strange as in the next chapter he goes to great trouble to define strategy.

This chapter is entitled "Construction." It concludes with a consideration of the action of strategy in producing strategic dislocation. The argument which follows does not seem to be conclusive. Is the strategy of indirect approach anything more than the application of the accepted principles of war, economy of force, mobility, and surprise?

Part II of the book contains an able analysis of the War of 1914–18, which has been added at the suggestion of critics who had seen the draft of Part I. It is valuable in that it gives a short and consecutive account of the strategy of the whole war. It is a matter for regret, I think, that these chapters did not precede those on Conclusions and Construction. The last sentence of the book reads, "It was the shock of being surprised and feeling that he was powerless to counter potential strategic moves which shook Ludendorff's nerve more than the loss of prisoners, guns, and acreage." This goes to confirm my impression that indirect approach is but a form of surprise.

It is to be hoped that Captain Liddell Hart will find himself able to give us a revised edition of this book, co-ordinating the whole of his study. If he does, I plead that he will abstain from the use of inverted

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commas as far as he can. To place a word in inverted commas tends so to emphasize it as to suggest that it carries some special meaning beyond that which is normally given to it. Such suggestion detracts from the clarity of the argument, for different readers will not always assume the same special meaning. If such a suggestion is not intended, then the inverted commas are not necessary.

N.W.N.-C.

THE GENERALSHIP OF ULYSSES S. GRANT.

By COLONEL J. F. C. FULLER, C.B.E., D.S.O.

(John Murray. Price 21s.)

This is an interesting, though not altogether convincing book. The author has avowedly set out to show that Grant was a general with a particularly keen strategical sense, and by no means the "butcher" he has usually been considered. His account of the fighting in the West, Fort Donelson, Vicksburg and Chattanooga, though vividly written, is somewhat too fragmentary in the main to follow his strategical deductions. In fact, one is inclined to think at times that the history is being used as a veneer to cover the "deal" or "rare wood," whichever it may be, of the author's theories as given in the *Foundations of the Science of War*.

When Grant becomes Commander-in-Chief, things improve, and there is a very clear analysis of the Wilderness campaign, of Grant's whole conception of the war, and of his dealings with Sherman at the time of the famous march through Georgia. Whether one agrees with the author's estimate of Grant's strategical acumen or not, one must be impressed by the Federal leader's strength and simplicity of character, and imperturbable nature.

This book undoubtedly throws some new light on a remarkable war, but unfortunately some of its military value is lost by the very poor maps provided, many of which face the wrong way to be read with the letterpress.

H.G.E.

MEMORIES OF FOUR FRONTS.

By LIEUT.-GENERAL SIR WILLIAM MARSHALL, G.C.M.G., K.C.B., K.C.S.I.

(Ernest Benn, Ltd. Price 21s.)

The author of this readable volume won a double brevet in the South African War. He had commanded a Mobile Column for six months in 1902 with success. When war broke out in 1914 he had only just obtained command of his battalion. How was it that with the reputation he had deservedly gained in South Africa he had not risen to higher command in the intervening years? The answer is to be found in his book. He was merely a fighting soldier, and a very modest one. It is in fact rather amazing that a man possessed of such modesty should have reached the position he eventually did, and it is quite obvious why he remained a company commander for ten years after South Africa in peace time. He found himself over age to compete for the

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Staff College, and he was unlucky in not being selected for an appointment which would have qualified him for the rank of Colonel long before he gained it.

The book is the simple story of a fighting soldier written from memory. It is not a history of the whole war, for it describes only what he saw with his own eyes and records what he thought of events at the time they occurred. But he gives his considered judgment of those events clearly and briefly, and for this reason the volume will be of value to the future historian of the Great War. The declaration of war in 1914 found him at Bombay in temporary command of the garrison of a great defended port. He must have regretted the want of a Staff College training when organizing the defence of the port and dealing with the many administrative problems it involved. That he felt the need of that training is apparent when he writes of the still greater problems which he had to face when Commander-in-Chief in Mesopotamia.

Fortunately, it was not long before his battalion was ordered home, and then sent to the Western Front. The short account he gives of his experiences during three months in France as a battalion commander are of great interest, and give promise of the future greatness in store for him. Here as elsewhere he saw the humorous side of things, and his comments are cynical, if not scathing. For instance, he writes: "The "absurd worship of ground as such was an absolute negation of our "previous military training, during these early months of trench war-"fare. Instead of holding a line of observation close to the enemy, and "a line of resistance farther back, almost every man was in front line, "and there were practically no reserves. The resulting casualties, the "weariness engendered in the troops, and sickness from trench feet, and "so on, could hardly have been borne by any less stout-hearted fellows "than British soldiers." And he has something to say about the holding of salients:—"The salient I have been discussing concerned only a "small number of men, but I wonder what history will say about the "continued holding of the Ypres Salient, with its record of 250,000 "dead? One was told it was held for sentimental reasons, but, if that "was the case, I can only say that such costly sentiment is out of place "in war."

Like another fighting infantry soldier, who also without Staff College training afterwards commanded a Corps (XIX), he had differences with the Higher Command as to the line to be held—so different on the map as compared with the actual ground: and he emphasizes the necessity of higher commanders going forward, however unwelcome their presence, not only to see the ground for themselves, but also to get personal knowledge of the conditions under which the men entrusted to their care are living, before issuing their orders.

From France he was ordered back to England to take up command of the 87th Infantry Brigade of the 29th Division. Though intended for France, the new division was eventually sent to the Dardanelles. The brigadier gives us an excellent, truthful and realistic picture of the landing and fighting at Hellas, the fighting at Suvla, and the subsequent evacuation. He gives us a true picture of the conditions ashore, and many sidelights, from the point of view of an infantry brigadier possess-

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ing human as well as fighting qualities, and many sound and true reasons for the failure of the expedition.

His loyalty to his Chief (Sir Ian Hamilton, who writes the Introduction to the volume) debars him from contrasting the position of the latter *vis-à-vis* the authorities in England as compared with that of his later Chief (General Maude), who was able to get all he asked for in Mesopotamia. Writing of the fighting at Hellas he says:—"I asked General "Hunter-Weston (commander of the 29th Division) what his candid "opinion was about the Gallipoli situation (in June, 1915). His reply: "'If you ask me as a soldier, I think it is rotten, but if as a man I think "it is splendid,' emboldened me to suggest that as neither the number "of guns, nor their supply of ammunition, was sufficient to prepare the "whole front for attack, it might be better to select certain tactical "points in the Turkish lines of defence, and take them *seriatim*. In fact, "I urged that we should ape the tactics of the Japanese during their "attack on Port Arthur. My suggestion was not, however, favourably "received. Indeed at this time among our leaders in France, and elsewhere, the theory of the 'break-through' was the predominating one. "No one seemed to have considered that, with the enemy reserves "unbroken, and the impossibility of our getting our guns forward in "time to support them, the troops who had broken through must be "overwhelmed."

He writes equally to the point when describing the condition of the 53rd Division at Suvla: "One could only wonder how the responsible "authorities at home could have ventured to send out such an untrained "formation to take part in so strenuous a campaign as that in Gallipoli. "Had the Division been sent to France it would not even have been put "into the trenches unless mixed up with experienced troops: it would "certainly never have been asked to carry out an attack until at least "it had undergone a course of training behind the lines. There was no "'behind the lines' in Gallipoli, and neither time nor opportunity to "train."

Sir William Marshall suggests the possibility of a single command in the Dardanelles campaign. Surely single command, as between the Royal Navy and the Army, could not have worked. It is doubtful whether the Fleet could have won through at the time of the Suvla landing. The effect of the land fighting would have had no effect on the Hellespont defences. It is to be hoped that the three Chiefs of Staff —Navy, Army and Air—will prevent a repetition of such a crime as the direction of the Dardanelles campaign in 1915.

From Gallipoli the scene is transferred to Salonika. Of events there the author provides an easily read account from the fighting soldiers' point of view only, but with some interesting sidelights thrown in.

Thence to Mesopotamia. The account of the operations from the re-organization onwards is given from a higher standpoint. The author's vision is enlarged as he rises in rank. It is to be regretted that he does not deal with the whole of the subsequent operations as he does with the recapture of Kut and the advance to Baghdad. More light is perhaps required on the failure, during the Kut operations, of the Cavalry Division to bridge the Tigris at the toe of the next loop upstream of the

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Shumran bend, in which a huge bridging train took part. Was it intended merely as a feint, as Sir William Marshall believes in spite of the fact that General Maude rode over to sympathize with General Crocker on his failure? The incident may have influenced Marshall in his subsequent relations with Crocker. It was not until Marshall discovered Cassels that Marshall, himself a mounted infantry leader of repute, had any good word to say about the cavalry—the only flaw in the tone of the whole book.

The subsequent smaller operations are of quite exceptional military interest, and will repay careful study, with maps. It is to be regretted that more are not provided with the volume.

Not the least interesting chapter is that entitled "The Persian Adventure." Sir William Marshall did not see eye-to-eye with the originators of that side-show. In fact, he admits that "he hated the whole business" of the "Hush-hush" Mission known as "Dunsterforce." It was said to be the product of the "Eastern Committee of the War Cabinet," and was generally attributed to Lord Curzon's influence in that Committee. It was designed to get through to the Caucasus, where its role would be to combine such unstable elements as the Armenians, Georgians, and Azerbaijans, and organize them into an army capable of resisting the Turco-German forces. These were credited with the intention of an eastward drive towards Afghanistan, and the raising of a Pan-Islamic offensive against British rule in India. The Indian Government had undoubted grounds, through its agents, for this belief, and a Turkish Division with German officers had actually been launched on the enterprise, preparations for which had been made by German agents, who we knew had reached Kabul. But before it could effect its purpose, the victories of General Allenby in Palestine necessitated its recall, though the fact was unknown to Allenby for some time. Thus before General Dunsterville's mission was started on its journey to the Caspian, the chief reason for it had, literally, disappeared.

Sir William Marshall writes: "I was not consulted in the matter, "and knew nothing of the political reasons which prompted its despatch, "but had the Eastern Committee done me the honour of asking my "opinion, I should certainly have advised against the whole project."

The volume concludes with an interesting chapter on the advance to Mosul, which shows the author to have been not only a resolute commander in the field, but also an able statesman and diplomatist. He realized that the whole of the Mosul Vilayet must be cleared of the Turks, and did not hesitate even in spite of the protestations of the French Agent and the complications which might, and did, arise out of the Sykes-Picot agreement of 1915. This he describes as "an example of counting "the chickens before they were hatched, which was hard to beat," but he forgets the equally premature undertaking of Sir Edward Grey to hand over Constantinople to Russia before the Dardanelles expedition was launched.

Throughout the book, as Sir Ian Hamilton says in his Introduction, facts and thoughts are given full expression, as they struck the author, or rather the fighting brigadier, the evident possessor of the simplest common sense, who is thus able to discard all but vital factors. That

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quality of common sense, combined with magnificent powers of endurance and physical and moral courage of the highest order, is the secret of the character of the distinguished author as revealed by his modest volume of memories.

H.B.W.

THE MAN BEHIND THE SCENES.

THE CAREER OF SIR BASIL ZAHAROFF, G.B.E., G.C.B., ETC.

By DR. R. LEWISOHN.

(Gollancz, 1929, 215 pp. Price 12s. 6d.)

It would be only reasonable to expect that the life story of Zaharoff would give scope for a noteworthy piece of biographical writing, but whilst the volume under review, coming as it does from the pen of the financial editor of the *Vossiche Zeitung*, can only be classed as journalism, it, nevertheless, provides a mass of facts of much value to the student. The book opens with a wearisome explanation of Zaharoff's ostracism from Athens when a youth, and interest is only kindled when we see him in 1877 entering the armament industry as the commercial traveller for the Nordenfelt Company at £5 a week.

Thereafter we realize what a fruitful period the next 40 years was to be for armament firms. The Russo-Turkish War had just closed and for the whole of this period practically every country in Europe was either at war, or arming against war.

Nordenfelt, the Swedish engineer, had produced a quick-firing gun which was superseded by Hiram Maxim's invention, and it was this latter gun which gave Zaharoff his start in life. The three men combined in 1888—Nordenfelt, the engineer, Maxim, the inventor, and Zaharoff, the salesman—and when inevitably inventor and engineer disagreed, Zaharoff followed genius. In 1897, Maxim having produced the "pom pom," the firm of Vickers, financed by Cassel, paid one million sterling for the Maxim works. For Maxim this was the end, and he left the company in 1911, but for Zaharoff it was the beginning of a new vista. From this point the narrative is virtually the story of the Vickers Company up to recent years. The Spanish-American War, the Boer War, the Russo-Japanese War and the Balkan encounters all assisted the firm from strength to strength. From military armament they went to naval requirements and later to aircraft and high financing. A great arsenal was constructed on the Volga, and the firm had, in addition, factories in Spain, Italy, Japan and Canada, when in 1914, with a capital of ten millions sterling, in which Zaharoff had considerable interest, they faced the World War. Thereafter nearly every country in Europe proceeded to nationalize the armament industry. In England, confusion was organized by Lloyd George into a Ministry of Munitions, which produced, amongst other things, 25,000 guns, 240,000 machine guns, 4 million rifles and 258 million rounds of shell, as well as 4 battleships and 5,000 aeroplanes. The company's capital rose to 13½ millions, and Zaharoff became the confidant of the Allied Prime Ministers.

After the war, the firm's capital was raised to 26½ millions sterling to

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cover all manner of new interests in Poland, Italy, and Spain. Then the crash came. Complication had produced inefficiency, and in 1925, when 12½ millions had been lost, the £1 shares were written down to 6s. 8d.

Meanwhile Zaharoff, now a Grand Commander of the Orders of the British Empire and of the Legion of Honour, born a Greek and always a Greek at heart, backed Venizelos and war with Turkey, being intoxicated by a vision of a Greater Greece in Asia Minor. In this ambition he had the support of Lloyd George against the opposition of France. Kemal's five-day march to the Aegean saw the complete demolition of this fantastic and short-sighted policy, and Zaharoff passed from the public gaze a disappointed man.

The author brings out the wonderful politico-industrial fabric which Zaharoff created to gain his desires, but though he had not the vision to realize the limitations of his countrymen, nor the new economic state imposed by the war, and thereby lost half his fortune, he was nevertheless astute enough to secure his personal financial independence by dabbling in banking, oil, and the ownership of the Casino at Monte Carlo; so he lives to-day, at the age of eighty, in at least physical comfort, on the Riviera.

The narrative has a distinctly German flavour, but nevertheless it has a great lesson to teach, and we cannot but marvel that such a purely individual question as the traffic in drugs should receive such universal and active condemnation whilst that pregnant international question—the traffic in armaments—suffers comparatively little restriction.

G.MacL.R.

MARLBOROUGH AND HIS CAMPAIGNS, 1702–1709.

With the Battles Described in Conjunction with Field Service Regulations.

By Lieut.-Colonel A. Kearsey, D.S.O., O.B.E., *p.s.c.*

(Gale & Polden. Price 3s.)

This book is similar to those already produced by the author on the Egypt and Palestine campaigns, and on the battles of Aubers Ridge, Festubert, and Loos, and it suffers from the same defects. The history of Marlborough's campaigns is here so condensed that many of the main lessons are missed. The mixed motives underlying the strategical and tactical schemes of this possibly the greatest of English generals must be understood before lessons can be deduced. The connections of the narrative of the campaign with *Field Service Regulations* are somewhat laboured and vague, and are unfortunately made with the 1924 edition.

This series of books would be of considerably greater value if the author confined himself to one short campaign, which he could analyze much more fully in conjunction with *Field Service Regulations*, and if even one general map were provided which could be read in conjunction with the letterpress.

H.G.E.

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AFGHANISTAN FROM DARIUS TO AMANULLAH.

By LIEUT.-GENERAL SIR GEORGE MACMUNN, K.C.B., K.C.S.I., D.S.O.

(G. Bell & Sons. Price 21s.)

Afghanistan must always be of interest to the soldier, not only because it has been the theatre of three British wars, but because therein lies the crux of the problem of the defence of India. We are therefore greatly indebted to Sir George MacMunn for bringing out a compact and very readable history of the country. It is difficult to think of anyone better qualified to write such a history than the author, who knows the Frontier well and has occupied many important positions at A.H.Q. India, concluding with that of Q.M.G.

We must disagree however with the author's contention on p. 2 that "Afghanistan is part of India, using that term in its widest sense." Geographically, Afghanistan is part of the Iranian plateau; ethnographically, the people are more akin to the Persians than to Indians; and linguistically, Persian is the vernacular of the western provinces as well as the court language, while Pashtu, the speech of the remainder, is an archaic dialect of Persian. It is true that the histories of India and Afghanistan are inseparably connected, but so, at one time, were the histories of England and Normandy. Indeed, Afghanistan has many times played the part in the history of India that Normandy once played in our history—a jumping-off ground for invaders who had come from further afield. The tribes have never looked on India as other than a country in which to loot, to conquer, and occasionally to settle.

The country assumed something like its present shape only in the eighteenth century; before that time, generally speaking, it was either a province of a larger empire, *e.g.*, Persia, or divided up among innumerable petty chieftains. Indeed, up to the eighteenth century the author records little, holding out a hope, however, that archæological discoveries may provide more material for history-making.

We are given a vivid account of the state of Northern India before the coming of the British. Between 1738 and 1800 there were 13 Afghan invasions, which ceased only when Ranjit Singh raised the Sikh power and turned the tables.

The author makes a good case for the British intervention which led to the first war, setting forth the point of view that, as the political heirs of the Moghal Empire, we undoubtedly had a claim to intervene in the affairs of a former dependency of Delhi. Fears of a Russo-Persian invasion were by no means groundless; while the H.E.I. Company desired, above all, peaceable neighbours, which meant good markets.

It was, therefore, with the peaceful intention of restoring a friend to the throne of his ancestors that we invaded Afghanistan in 1839. The great Duke of Wellington had, however, recorded his opinion that it would be very easy to get into the country, but very hard to get out, and events were to prove him right.

The author is careful to show the Kabul disaster in its true light, and points out that Pollock and Nott amply avenged it, but adds that it destroyed the legend of British invincibility, and so may have been a

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contributory cause of the Indian Mutiny. The lessons of the war were admirably summed up by Sir J. Nicolls, the then Commander-in-Chief, whose comments are given on p. 154 of the book.

The second war is treated more briefly than we would like ; the author gives deserved credit to Sir F. Roberts for his march on Kabul from the Paiwar Kotal, a feat which has not attracted anything like the attention of his Kabul-Kandahar march.

The policy laid down at the end of that war lasted until 1919, when Amir Habibullah was murdered and Amanullah reigned in his stead, invaded India and got beaten for his pains ; the author does not mention that it was the bombing of Kabul by a single British aeroplane which decided the Amir to sue for peace. Unfortunately, the fact that at the subsequent peace the Amir got nearly all he asked for, and the retrogression of the British Frontier in the Khaibar in 1921 by a few hundred yards, created the impression among the Afghans that they won the war.

Had the publication of the book been delayed by a few weeks, the author would have been able to record the accession of Nadir Khan to the throne, the general who gave us a good deal of trouble in the Kurram in 1919. For the moment all is quiet, but with spring fighting may start again, which Nadir Khan, with depleted coffers and arsenals, may find it difficult to quell. Then should the Tajiks and other tribes in Northern Afghanistan elect to join the Soviet republics that bear their names on the other side of the border, it is difficult to see how Soviet, and ultimately British, intervention, can be avoided. The author might have concluded by referring to the five-centuries-old prophecy of a terrible battle to be fought on the Dasht-i-Bakwa, half way between Kandahar and Herat, a prophecy which the Afghans say refers to the British and Russians.

As regards the style, in his quest for telling phrases, the author sometimes ceases to be intelligible. What, for instance, is the " asbestos curtain of imagination " ? There are many unduly long sentences ending with a dreary succession of relative clauses introduced by " and which." Then why does the author, in common with most of our race in India, refer to " Europeans " when " British " is what he means ? " European " includes Bolsheviks, Germans and others. But we must be grateful to Sir George for using a light and bright style where most historians are heavy and dull.

The map, excellent *sui generis* (though, curiously enough, it omits the Nowshera-Dargai railway constructed as long ago as 1900), does not illustrate the text. We search in vain for the battlefield of Maiwand, for instance, and for many of the places mentioned in the very interesting chapter on pre-war plans of campaign. We would have liked, too, a map of Northern India to illustrate the various Afghan inroads in the eighteenth century, and something better in the way of sketches to illustrate battles, etc.

On the whole, however, the book is a very valuable addition to the literature on the subject, and no military library should be without it.

F.C.M.

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THE BIRTH OF AIR DEFENCE.

"AIR DEFENCE," by MAJOR-GENERAL E. B. ASHMORE, C.B., C.M.G., D.S.O.

(Longmans, Green & Co., Ltd. Price 8s. 6d. net.)

To the future historian the Zeppelin raids of 1915 and 1916 will only be of interest as giving examples of great gallantry by both sides. Even the small searchlights of those days could not fail to pick up so large a target, and it only needed night-flying machines of the most limited performance to put a stop to this form of attack. That the performance of our machines was indeed limited is shown by the sad number of pilots who were killed in landing after having gone up in attempts to engage the raiders.

DAYLIGHT RAIDS.

The bow-and-arrow era of aerial warfare may be said to have begun with the daylight aeroplane raids of the German 3rd Bombing Squadron in May, 1917. Hitherto, aeroplane attacks on this country had, with few exceptions, been carried out by single machines. Then we got the result of the experience in the Near East of the 1st Bombing Squadron.

In May, June and July, 1917, there were six daylight raids on England. Three did not get beyond the coast, and three came well inland. In the latter, 359 persons were killed and 850 wounded by bombs, and 11 killed and 74 wounded by our own anti-aircraft gunfire. The average number of bombers was 17, and of defending aircraft 88. In the first of these attacks, one German machine was damaged in an aerial combat, and, in the third, one was damaged by anti-aircraft gunfire and finished off later over the sea by one of our machines. These figures speak for themselves. The attack had the complete mastery of the air.

"The bulk of our pilots did not succeed in finding the enemy at all, "and it is in this point that lies the main problem of air defence. Owing "to the difficulty of picking up one aeroplane from another in the air, "it is essential to give information from the ground, where observation "is easier and aircraft can be seen at far greater distances. And, to "render this information timely and effective, a great system of ground "observation and control is required."

The last sentence summarizes General Ashmore's gospel.

THE END OF THE DAYLIGHT RAIDS.

On 31st July, 1917, the London Air Defence Area was established, combining all defence units, aircraft, A.A. guns, searchlights, in one command under General Ashmore. Communications were improved, so that warning messages could be quickly received from the coast. A gun barrier was placed round London about 20 miles out, to break up hostile formations, so facilitating attack by our defending aircraft by depriving enemy machines of mutual supporting fire. Careful arrangements were made to prevent our guns from firing on our own machines by giving definite areas to each. At searchlight stations large white arrows were placed which could be pointed in the direction of hostile aircraft seen from the ground. These could be seen from a height of 17,000 feet.

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As a result of these measures, the last two daylight raids, on 12th and 22nd August, 1917, were both headed off from London by the appearance of an overwhelming force of defending aeroplanes.

"The raids of 12th and 22nd August produced a decisive effect on "the mind of the German commander, who reported that 'the increased "'strength and better organization of the defences had now made it "'inadvisable to attack unless with machines that would fly loaded "'over 10,000 feet, or under cover of darkness.' Accordingly, no "further attempt was made to attack by daylight, and day flights over "this country were in future confined to a few reconnaissances by single "machines carrying no bombs."

Night Aeroplanes.

Night attacks began on 3rd September, 1917.

"At that time there seemed to be no means of meeting this form of "attack. . . . Searchlights were not sufficiently advanced in training "or material to pick up and hold an aeroplane; although they could "deal pretty well in good weather conditions with the larger, slower-"moving airship. The lights being unable to illuminate a target, the "anti-aircraft guns had nothing to aim at and could only fire in the "direction of the sound. It was necessary to find some new means of "employing them until such time as the searchlights improved.

"The slow types of machine which had been successful against the "airships were quite incapable of catching a Gotha, even if they could "find one. To fly the more efficient scout machine at night was not "considered possible. This opinion was impressed on me by the "R.F.C. commanders, who were men not in the least likely to under-rate "the possibilities of their pilots."

The raid of 3rd September is memorable for two things. First, of immediate importance, a system of barrage fire to sound was evolved by Colonel Buckle, commanding the Chatham defences. Barrage fire is looked upon nowadays as the last resort, almost the forlorn hope, of the defence, when all other means are precluded by adverse weather conditions; but throughout the winter of 1917–1918 it was the only weapon that was effective in any degree. The expenditure of ammunition was enormous and the results in planes brought down were very meagre; but, although insufficient to stop raiding, barrage fire did head off many enemy machines and so gave a very real measure of protection to London at that time.

"Secondly, of our sixteen machines that went up, three were Sopwith "Camels, efficient fighting scouts. This was perhaps the most important "point in the history of air defence. It falsified the official view, so "recently expressed, that flying these machines at night was impossible."

The scout, now called the single-seater fighter, is to-day recognized as the primary weapon against bombers, and throughout the main period of the night attacks, 3rd September to 7th March, they became available in rapidly increasing numbers. But, although by balloon aprons the path open to the enemy was restricted to a narrow strip below his ceiling, the difficulty of gaining contact with him was not then overcome. "Out of every eighteen of our pilots that went up in defence,

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" seventeen saw nothing of the enemy. The five raids of this first " quarter of 1918 produced only eighteen combats, only one Gotha was " brought down. We were doing some fending-off, but, so long as the " Germans could count on returning home safely, we were doing nothing " to put a stop to the raids. Hope for the future, and in my case a " certain faith, rested in the new control system and the wireless tele- " phone."

This control system was an intelligence organization by which continuous track could be kept of every enemy machine. It was perfected before the end of the war, but never actually tried out in a raid. It could give useful information to the artillery of the defence, would be of immense help to the civil authorities responsible for the issue of air raid warnings, and would, it was hoped, enable fighter squadrons to be directed by wireless towards the enemy.

But all this would be useless without efficient searchlights. It is no help to a fighter pilot to be in the same area as an enemy if, when there, he cannot see him. The failure of our aeroplane defence must very largely be set down to the ineffectiveness of our searchlight units at this time, though this does not in the least disparage the personnel of those units. The lights were in most cases not powerful enough, and the equipment could not be readily handled : this form of warfare was new, and the tactical principles which can only be deduced as the result of experience had not yet been thought out ; it being war time, no practice could be obtained except against enemy aircraft, and, though raids were too frequent for the population of London, they were insufficient to allow a very rapid advance in training in view of the handicaps just mentioned.

That such conditions are a thing of the past is shown by the efficiency in recent years, in their practice camps, of both regular and territorial searchlight units.

The importance of searchlights was better illustrated in France, where, through continual practice, they reached a very high degree of efficiency. One squadron of night-fighting machines (No. 151 Squadron) was sent out to defend Amiens in 1918, and achieved conspicuous success. That it could have accomplished nothing without searchlight co-operation was most generously acknowledged.

From March, 1918, onwards, the Germans had full employment for all their airmen in France. Of greater value to them than the result of any raid was the fact that, at a time when we needed every possible man at the front, the London defences consisted of 266 guns, 353 searchlights, 159 efficient day fighters, 123 efficient night fighters as well as numbers of older machines. In addition there were the defences of Portsmouth, the Midlands, and the North.

A last raid on London was carried out on Whitsunday, 19th May, with between 30 and 40 machines, nearly twice as many as in any previous attack. The two months-respite had been of great value to the defence. The improvement in the searchlights was shown by the fact that about one in six of our pilots picked up an enemy machine. For the first time, the defence showed signs of getting on terms with the enemy in night attacks. Thirteen enemy machines succeeded in getting through

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and dropping bombs on London, but, in one way or another, ten raiders were brought down.

"No scale of defence, however great, can secure complete immunity "from bombing; but by suitable arrangements the attacker may be "made to suffer such casualties that his efforts will die out. So long as "the London defences could only fend off the whole or part of the "bombing aircraft, attacks continued. When, in addition to fending "off, the defence could produce heavy casualties, as in the case of the "airships, and again in the case of the day aeroplane raids, the par-"ticular form of attack ceased. It was so with the night aeroplanes. "After the losses of 19th May, the Germans no longer attacked us, and "London was free from further trouble."

In each case the defence got the upper hand as soon as it could solve the problem of making contact with the enemy. In the daylight raids this was effected by ground signals. In the night raids the fighters began what is now normal tactical practice, flying towards the intersection of the searchlight beams, just as, in the past, armies used to march towards the sound of the guns.

The Future.

General Ashmore does not belong to the counter-bombing school, whose doctrine was last year described by one paper as being that "the only way to protect Westminster Abbey is to destroy Notre Dame." Writing, however, in another connection, of the raids at the end of 1917, he mentions:—

"There was at this time a tremendous public outcry for reprisals on "German towns. The outcry was freely expressed in Parliament and "in the newspapers. Von Hoeppner has an interesting comment on "the difference between the attitude in London and in Paris under the "stress of raiding. While the London Press cried for reprisals, he says, "Paris wanted to arrange with the Germans a mutual cessation of raid."

He would also like to see all air defence, guns, lights and aircraft, put entirely under the control of the Air Ministry, both in peace and war. For the defence of Great Britain alone this would have many advantages, but it seems very probable that, as in the last century, having finished one big war, we shall only have little wars to deal with for some time. It is easy to think of four or five possible theatres of small wars where air defence would be needed.

In the field, the R.A.F. will be most unwilling to reserve squadrons for what seems to be passive defence, nor could they be made full use of. The point is illustrated by what General Ashmore says about coastal raids: "It must be accepted as an axiom that no practicable scale of "*aeroplane* defence in England can be effective against surprise air "attacks on the coast-line. In fact, home defence on a large scale by "aeroplane has, in practice, to be limited to important areas—London, "for example—that are well inland. Anything in the nature of con-"tinuous patrols, flying day in and day out, in anticipation of raid, is "out of the question for reasons of expense—expense in men, money "and material.

"Such defending patrols as we can afford take time to get to their

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" fighting height. We gain this time by arranging our patrol lines some " way inland, leaving between them and the coast a zone that will take " the enemy an equivalent time to cross."

The above applies to forward areas if " front line " is read for " coast-line." Our bases, too, will almost always, presumably, be on a coast-line. For air defence in the field the normal weapon will therefore be the anti-aircraft gun, and it is difficult to see that anything but confusion would arise from making a sort of R.A.F. Marines out of A.A. batteries and searchlight companies in the case of a war overseas. Our army is also too small for us to be able to have duplicate organizations allowing for different possible kinds of war.

One of General Ashmore's contentions is incontrovertible. As hostile bombing may be expected within a few hours of the outbreak of war, the peace and war establishments of air defence units should be the same. But it is difficult to see how this can be arranged, in view of perennially increasing financial stringency. The units allotted to the defence of London are, moreover, all Territorial. It might, perhaps, be possible to separate these from the rest of the T.A. as a special kind of militia, who would be liable to be called up for service during the precautionary period without embodiment by Parliament, as though they were Class A reservists. It would be an easier matter to arrange that all reservists earmarked for regular A.A. units should be of Class A, remaining in that class throughout their reserve service, and not only for one year.

J.S.B.

" COMMANDO."

By DENEYS REITZ.

(Faber & Faber. Price 15s.)

This Boer journal of the Boer War is introduced by General Smuts, under whom the author soldiered, both in the Boer War and in the Great War.

Colonel Reitz, starting at the age of 17, served the South African Republics in the field from the very beginning to the Peace of Vereeniging, and he served the British Empire from de la Rey's rebellion to the Rhine, where he led the 1st Bn. Royal Scots Fusiliers.

For the last 30 years, General Smuts has shown himself beyond all doubt to be a great patriot of South Africa, and he is now one of the greatest Imperialists of the present time ; Colonel Reitz, proud to serve under him, is a worthy follower.

This journal was written immediately after the Boer War, when Colonel Reitz and his brother were suffering self-imposed exile in Madagascar rather than live under British rule. It is the vivid story of a true patriot and of his development from boy to man. The early Boer successes—Dundee, Nicholson's Nek, the encircling of Ladysmith—meant to the boy rather a good game. All lived a free and practically independent life, going and coming as they pleased—" we thoroughly enjoyed the business of besieging Ladysmith, sniping at outposts, riding from camp to camp to pay visits and making regular excursions to see the guns fired into the town." Then gradually things were not quite such fun ; attacks were bungled, his friends were killed or maimed, the

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British would not give in, and in fact soon, by sheer numbers and ubiquity, overran the country. There followed the carrying on of the war by guerilla tactics—commanders of all strengths operating when and where they could. The weaker brethren surrendered or went home, but the remainder, all seasoned fighting men, rallied to the side of Botha, Smuts and other leaders, and the war dragged on for two years more. These two years contained constant suffering from starvation, cold and wet, constant alarms and pursuits, and although he, and the various commandos to which he belonged, had many successes in action against British columns and posts, still all the time it was a losing fight. "While matters stood thus well with us, the situation in the two Republics up North was far otherwise. Lord Kitchener's relentless policy of attrition was slowly breaking the hearts of the commandos." The inevitable end arrived, and Reitz accompanied General Smuts to the discussions for peace and the bitterness of defeat. In connection with this, he tells an amusing story of how, when the safe conduct for General Smuts provided also for a secretary and an orderly, Reitz chose to be the orderly, as he thought it meant an aide-de-camp, leaving a companion to be the secretary. On arrival in the British lines, when General Smuts was taken to lunch, Reitz found himself led to the kitchen to feed with the batmen, and subsequently, for the train journey to Port Nolloth, he was put aboard an open cattle truck with the baggage. At the next halting place, General Smuts explained the situation and Reitz's "promotion from batman to field rank in the course of one morning was the quickest known in any army."

There are many lessons to be learnt from the book, both practical and psychological. The Boer's outstanding advantages were, of course, their mobility and markmanship. Again and again the superiority of their shooting comes out, not only their accuracy at long ranges and skill in firing from behind cover, but also their unfailing success when one or both sides were surprised. Colonel Reitz is, however, also very strong on the mistake which Lord Roberts made in ordering the destruction of farmhouses and crops and constructing concentration camps for the Boer women and children. "The intention was to undermine the morale of the fighting men, but the effect was exactly the opposite from what I saw. Instead of weakening, they became only the more resolved to hold out, and this policy, instead of shortening the war, prolonged it by a year or more." "Frightfulness" employed against the wrong people has always the wrong effect. Colonel Reitz is also rather bitter against Lord Kitchener's proclamation that all prisoners taken in khaki should be shot, as he claims that in many cases captured khaki uniform was the only clothing that could be had. (At one time Reitz was wearing a grain bag as his chief garment; at another time his entire wardrobe was a blanket and a pair of sandals.) He acknowledges, however, that at least twice in one day his khaki uniform saved him from unsuspecting soldiers. He is complimentary to the British, however, in all respects on the care taken of Boer wounded left behind, and on the gentlemanly way in which they waged war—"with one exception, I had no unpleasant word from officer or private in all the time that we were out against them."

ANON.

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MAPS OF IRAQ, WITH NOTES FOR VISITORS.

(Published by the Government of Iraq. Price 6s. 6d.)

This volume, containing both notes and maps, is published by the Government of Iraq, but in the foreword to the original edition it is stated that the "Notes for Visitors" should not be regarded as containing the official views of the Ministries of the Government. The maps, which originated in the Report of the Iraq Public Works Department for 1924–1927, are presumably the only official part of the work, and the notes are compiled from unofficial contributions.

The whole of the notes are full of really useful information, and it is pretty obvious that most, if not all, of the unofficial contributions come from the pens of officials who know exactly what information is wanted by visitors to Iraq. Such information has been hard to come by in the past.

The sections dealing with the history of Iraq, its present constitution, its population and its great tribes are of general interest. There is a useful temperature chart on page 7 which not only gives the average monthly maximum temperature in Baghdad but also tells the intending traveller what sort of clothes are worn by Europeans at different times of the year—information which many visitors have been unable in the past to obtain.

Following this are sections of the main routes of entry into the country and methods of transport within it, together with passport regulations, etc. Full notes are given of the various overland motor routes from Europe, viz., Beyrout–Damascus–Baghdad, Aleppo–Mosul, Aleppo–Anah–Baghdad, Darbisiyah–Nisbin–Mosul.

As many as 1,900 persons have travelled in one month by the Damascus–Baghdad road, but the combined number of passengers by the other lines does not exceed 3,000 in the whole year.

Notes are given on the coinage, the antiquities, the ancient sites and the ancient irrigation of Iraq.

There is an account of the educational and medical facilities in the country. Agriculture, export and transit trade are also touched on.

The notes on the Iraq Police and the Iraq Army are interesting. The former are a really first-class service, and no visitor can fail to be impressed by its efficiency. The Iraq Army is described as a "healthy infant," and a somewhat glowing account is given of it.

A paragraph is devoted to the Iraq Automobile Association, which is willing to admit and help travellers motoring in the country.

There are also full notes on the postal facilities, postal rates, etc.

The Government regulations for ladies travelling in Iraq are fully given, and should be most useful to any ladies who may wish to tour the country. In many districts ladies may only travel by certain routes and even then must be "accompanied" by some male escort. Ignorance of these regulations will lead to "unaccompanied" ladies' tours being curtailed by local officials.

An Appendix and notes on travel in Persia is added at the end of the volume.

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The maps are most useful, but, except to those who know Iraq, give the impression that there are really good roads all over the country.

There is a warning in page 7 of the notes to the effect that there are not more than 20 miles of metalled road out of the 4,800 miles of track shown in the maps.

These unmetalled tracks go out of commission after rain, and are not roads in the European sense of the word.

The policy has been to spend what money was available for the roads in opening up a number of tracks over which traffic can move during the greater part of the year, rather than to concentrate on making a few really first-class roads.

Generally the notes and maps are most valuable, and are recommended to anyone who is thinking of visiting Iraq, either on pleasure or duty.

The solution used in binding the book is specially prepared to render the work impervious to the ravages of insects—a very useful precaution. The resulting volume is 8½in. x 13½in. by about ¼in., and is an awkward size to travel with. It is obtainable from the Crown Agents to the Colonies, 4, Millbank, London, S.W.1, and from various other publishers, and costs 6s. 6d.

G.C.G.

THE WORLD, THE AIR AND THE FUTURE.

By Commander Sir Dennis Burney.

(Knopf. Price 21s.)

Sir Dennis Burney has been well known for a number of years as an expert and enthusiast in airships. He has voiced his enthusiasm many times in Parliament and outside, and the effects of his enthusiasm have been that not only has some £400,000 been advanced by the British Government as a subsidy for his Airship Guarantee Company for the construction of one airship, the R.100, but a second airship, the R. 101, has been constructed under official enterprise, together with bases and mooring masts abroad. The R.100 and R.101 are now complete and undergoing their trials, and it is at this moment that Sir Dennis Burney launches a bomb. " Let me say at once that, as a result of the last seven years' investigation and work upon the R.100, I am firmly convinced that the airship enthusiasts not only overstated their case, but failed to realize that a vessel that could neither make a landing without elaborate extraneous aid, nor be housed or rigidly secured in rough weather, must always remain of doubtful value for commercial purposes."

Was not this said by " Neon " in 1927 and scoffed at ?

It may be mentioned that he really came to this conclusion by 1926 before the R.100 was half built, but, rather than confess failure at the time, he decided to continue construction (and also incidentally not to give any warning which would have affected the construction of the R.101). Sir Dennis Burney blames the Government for spending public money unnecessarily on the R.101 and on airship bases ; he does not seem to consider the hundreds of thousands which were spent unnecessarily owing to his silence.

While continuing work on the R.100 he concentrated on the theory and

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design of means to overcome his objections. He laid down "three distinct problems to be solved :—

(1) "How to increase the cruising speed from 70 m. p.h. to 90 m.p.h.
(2) "How to evolve a method of putting a vessel into a shed and taking "her out, in any average weather, by mechanical means.
(3) "How to develop an airship which could alight and moor without "extraneous aid, and at places at which no preparation had "been made."

He claims to have solved them respectively by the following :—

(1) The Howden propulsion system using two fuels, one a gas and the other a liquid. Equilibrium is maintained by this and weight is also saved. Further saving in weight is gained by the higher compression ratios of the engines.
(2) The mooring and docking raft. Claws on a rotary raft clasp the airship attached to a telescopic mast and the whole is then revolved in front of and run into a floating shed.
(3) The "Elliptical" design. The airship is to have an ellipse as cross section instead of a circle as at present. This is claimed to reduce resistance to a side wind and danger of overturning, both by shape and diminished height. The principal advantage claimed is, however, that two long floats can be fastened on the lower side as hulls. The object of these is to enable the airship to alight on water in the same manner as a flying boat. The theory is that, as she alights, her hulls may be automatically filled with water by means of scoops ; the weight of water added to the ship will hold her down and she can then be moored to a buoy or be warped into a shed.

Neither of these two last theories have so far got beyond theory or models, and the present ships, R.100 and R.101, do not appear likely to be of use in substantiating either theory.

Sir Dennis Burney fills up the rest of his book with long dissertations on such questions as Empire Development, the Re-orientation of Defensive Power, and International Peace. One gets the impression that the master key to all problems is "An airship." Like most enthusiasts he wearies one after a time with this universal panacea.

One chapter on "Heavier-than-air Craft" is written by Mr. Neville S. Norway, where he discusses both the land aeroplane and the flying boat. Although nearly the whole book vaunts the airship, one feels that in this one chapter is demonstrated the best hope for aircraft development in the future.

H.N.K.

WONDERS OF ENGINEERING.

By ELLISON HAWKS, F.R.A.S.

(Methuen & Co., 1929. 185 pp. 16 plates and 28 diagrams. Price 6s.)

This book consists of a popular description of certain outstanding civil engineering achievements under such branches as bridges, docks, harbours, canals, dams, and tunnels. The history and theory underlying each branch is lightly touched upon, and the leading dimensions and

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costs of the projects described are given. The main interest, however, lies in the descriptions of how each of a large number of famous engineering monuments came into being. In the bridge section reference is made to the original disaster occasioned by soldiers marching in step over a bridge at Angers in 1850, when 226 men were killed. The difficulties of bridge building 100 years ago are instanced by an account of the Menai Bridge works, and the progress in suspension bridge design is illustrated by comparison with materials and methods used on the Hudson River Bridge, to be opened in 1932. It willi nterest readers of the *R.E. Journal* to learn that the contractor's designs for the latter bridge, which has a clear central span of 3,500 feet, with towers twice as high as St. Paul's, were, as is customary in the U.S.A., scrutinized by the U.S. Army Engineers before the project was approved. This section closes with an account of the tragic failures of design and erection on the Quebec cantilever bridge.

In the Dock section, much data is available as to the Port of London, whilst the recent improvements at Tilbury, which provide dry dock accommodation for 30,000-ton liners 40 miles from the sea, are mentioned. The Gladstone Dock at Liverpool is described, its chief feature being its ability to receive vessels at practically any state of the tide, which has, at Liverpool, a range of 30 feet. The floating docks at Southampton (60,000-ton lift) and Singapore (50,000-ton lift) are briefly mentioned.

The irrigation schemes at Assouan, Delta, Assiot, Zifta and Esneh demonstrate forcibly all that British engineering genius and suzerainty has done for Egypt, a fact on which a little more stress might be laid at the present juncture. The Lloyd Dam, which will irrigate 7½ million acres, and is estimated to increase the annual wealth of India by 19 millions sterling, should also provide food for thought for that vocal fraction of India's population which is now demanding complete independence.

The great achievements of Canada in hydro-electric power schemes are exampled by the Chippewa scheme, producing half a million horse power, and the Gatineau River scheme, designed for 3–4 million horse power and now nearing completion. No mention is made of the Chosen (Japan), Grimsel (Switzerland) or Shannon hydro-electric projects, all of which are now nearing completion and provide approximately 1/4 million horse power each.

The romance of the Panama Canal is described at length and though tribute is paid to General Gorgas, the medical authority who made the work possible, it is suggested that an account of this project is incomplete without the name of that great military engineer, General Goethals. The Suez Canal is not referred to, and apparently an error is made at the foot of page 147, when describing the effect of the deepening of the Welland Canal. This Canal is due for completion this year, and will contain the largest lock in the world, 1,380 feet long.

The tunnels described include the Mt. Cenis, which cost £225 per yard, compared with the St. Gothard of £142 per yard, due to the use of dynamite in place of powder and improved pneumatic drills; the Simplon, which only showed an 8-inch error of direction in 12½ miles; the Mersey Tunnel, now under construction at a cost of £5,000,000; the Otira, in

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New Zealand, and the Moffat in the American Rockies. The Holland Vehicular Tunnel under the Hudson at New York, an epic of engineering skill and tenacity, is omitted, whilst all too little is made of the uncanny skill required to build the Tube Railways of London, and effect such reconstructions as Piccadilly Station.

The book closes with a description of the Collard Scheme for a Channel Tunnel at a cost of £189,000,000, and the rehabilitation of Spain is suggested as a possible result of the Gibraltar Straits Tunnel, now under discussion.

G.MACL.R.

HIGH VOLTAGE CABLES.

By L. EMANUELI.

(Chapman & Hall, Ltd. Price 8s. 6d.)

This is not a text book in the ordinary sense, but simply a reprint of a series of five lectures delivered in the University of London.

The author has a very high international reputation as a cable designer and manufacturer, and the results of research given may be considered as authoritative.

In the first two lectures manufacturing methods are briefly described, also the methods of measuring and stating the electrical and mechanical properties of the insulating paper and impregnating oils separately and of the paper when impregnated. The variations of dielectric strength and dielectric losses with D.C. and A.C. of various frequencies are clearly explained.

The third lecture deals more fully with the radial and tangential voltage gradients in the dielectric of the ordinary belted type of three-phase cable, and refers briefly to the "Hochstadter" and "TSL" designs, in which the tangential voltage gradients are eliminated.

On page 62, the author states that the tangential stresses in a belted cable are of the same order as the radial stresses. This does not appear to agree with the curves given on the same page.

The electrolytic method of exploring model electrostatic fields is also described in this lecture.

The fourth lecture deals in greater detail with impregnation, the effect of temperature cycles on the cable as a whole, the formation of voids due to the inelasticity of the lead, the ionization of gas in these voids and the consequent gradual deterioration and ultimate breakdown of the dielectric.

Lecture five explains the behaviour of the cable when bent, the variation of dielectric losses with voltage and temperature, and the importance of the "time factor" when specifying the breakdown voltage of a cable.

In conclusion, various theories of cable breakdown, and devices to avoid or minimize ionization are given. It is evident that the only sure method of preventing ionization is to use hollow-cored cables and permit free expansion of the oil to take place into special tanks connected therewith.

The book is a very useful addition to the literature on the subject, and should be found useful in technical schools. It is well printed and the very few printer's errors will be obvious to the reader.

W.M.

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ART OF RAPID READING.

By W. B. PITKIN.

(McGraw Hill Book Co., 1929. 233 pp. Price 12s. 6d.)

The title suggests a book of priceless value in these days of multiplication of the written and printed word, and the predominance of paper over the sword, and therefore at first reading, it may be found a little disappointing. The secret of the art is so very simple and short to tell; the acquisition of facility in the art so very difficult and laborious. The key to success is the formation of a state of mind which reads with an object. The various interests selected, it remains to discard everything else ruthlessly. Again, when reading a selected article or book, it is essential to be able to seek out the key points and to study them in detail with the omission of the less relevant portions.

The author hopes that all serious writing may eventually be arranged under the following headings: statement of subject, details, summary of facts, conclusions, bibliography.

The bulk of the book contains exercises calculated to train the eye to read quickly and considerable space is devoted to a discussion of bad habits, and unsuitable conditions, which reduce the ability to concentrate on the selected reading. Some hints for rapid reading are: Get the broad picture first, then go back and read carefully the details of interest. Read complete sentences, not odd words when skimming. Learn all the meanings of all the technical terms used in the particular branch of matter to be read. Take no notes as you read. Make them afterwards. The more you read, the better you read, but always read objectively. "Skimming" is defended as not mere eye skimming plus mind wandering, but is shown to require considerable and ever watchful concentration to pick out the salient facts.

This book should appeal to those who have been able to complete a course in Pelmanism.

G.MacL.R.

RADIO TRAFFIC MANUAL AND OPERATING REGULATIONS.

By R. L. DUNCAN and C. E. DREW.

(John Wiley & Sons, 1929. Price 10s.)

This handbook is from America, and is well described by its title. Beginning with instructions on learning the Morse code, it goes on to give all the abbreviations, code signs, and regulations which are in force for the expeditious handling of wireless messages at sea. The text of the International Radio-Telegraph Convention is given in full, though the date of it is not mentioned.

K.H.P.

ELEMENTS OF RADIO COMMUNICATION.

By J. H. MORECROFT.

(John Wiley & Sons, 1929. 269 pages. Price 15s.)

This book is an introductory volume to *Principles of Radio Communication*, by the same author. It is an American book, using American terms and dealing with American practice throughout. Where references are made to European practice they are of little value.

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The book begins by formulating the laws of electric circuits, and goes on to apply them to radio communication. A very good chapter on valves—or tubes—is followed by explanations of wireless telegraphy and telephony, and the book ends with a chapter on receiving sets, some problems, and a short, rather inadequate, index.

The middle part of this book is the best—the explanations of valves and valve circuits, and the various systems of telegraphy, being particularly clear. The first chapter employs no mathematics, and does little more than state, in some cases rather loosely, the principles of A.C. circuits, making no attempt to explain them. This would not be enough for anyone studying wireless seriously, but a more adequate treatment can be obtained from many other books.

The book is fairly up-to-date, and includes treatment of the screen grid valve and quartz oscillator, but beam wireless and mains units receive scant treatment, while the pentode valve is not mentioned.

No answers are given to the problems at the end of the book, and in some cases they are not soluble by reference to the text.

K.H.T.

TELEGRAPHY AND TELEPHONY.

By E. MALLETT.

(London, Chapman & Hall, Ltd. 408 pages. Price 21s.)

This book deals mainly with the theoretical principles of electrical signalling, the author's intention being to bridge the gap between the elementary textbooks and the many advanced treatises on particular aspects of the subject.

105 pages are devoted to line telegraphy, 168 to line telephony, 91 to wireless telegraphy and telephony, and 35 to appendixes dealing with the more difficult mathematical formulæ and solutions.

The first part opens with a description of the simpler telegraph apparatus and systems, and concludes with details of high speed apparatus. The theory of the transmission of telegraph signals, and the effects of the various factors causing attenuation and distortion of the signals and time lag in their reception are all clearly explained, as are also the various methods adopted to increase the speed of signalling on long lines, viz., repeaters, condensers, "curbing" and "loading." The effects of the various factors causing attenuation and distortion of the old "K.R." law now ceases to apply.

In the second part, telephone apparatus is described and explained, including the Strowger automatic exchange equipment. The theory of sound waves, their conversion into electrical signals and the theory of their transmission along line conductors, also artificial lines, filters, and superimposed telegraph and telephone circuits, are all ably dealt with. The importance of "loading" is again emphasized. The thermionic valve and the nickel iron alloys such as "Permalloy" will, it is expected, make transatlantic telephony possible in the near future.

A chapter is devoted to the theory of the thermionic valve and the important use of these valves as amplifiers and repeaters in ordinary

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line telephony and as oscillators in the " wired wireless " system which was largely used in the field during the European War of 1914–18.

Part III deals with the production, radiation and reception of electro-magnetic waves and the principles and advantages of the various methods of production, viz. : Valve, alternator, arc and spark are described. The various methods of coupling both in transmission and reception are clearly explained, and the subject matter as a whole maintains a high standard.

The book will be found invaluable for the engineering student who intends to take any of the more important academic or professional examinations in " light " electrical engineering. A good mathematical knowledge is required (70% of the book is applied mathematics), but third year students at universities and technical colleges should find no difficulty in this respect.

A very useful list of references for further reading is given at the end of each chapter.

W.M.

OVERHEAD POWER LINES.

By CAPTAIN W. M. N. MORECOMBE, R.E.

(Chapman & Hall. Price 15s.)

A book which every Engineer officer who is concerned with power lines of any description would do well to possess—it should be very useful to all electrical and mechanical officers, especially if they are likely to be going abroad, and more so if going for a tour in India.

The Engineer officer at home seldom is confronted with more than the simple problems of barrack distribution schemes ; abroad, and in India in particular, however, transmission and distribution schemes over large cantonments are still being carried out.

The author has set out in a very clear and concise way the problems connected with the design and erection of overhead power lines, of the magnitude such as are more likely to be met with by R.E. officers. With the aid of extremely clear diagrams and curves, he has assisted the designer of a line and enabled him to obtain the results of complicated calculations in an easy manner. He is also to be congratulated on having the diagrams, illustrations, etc., put in the text, thereby making the problems, etc., easy to follow.

Although the author deals primarily with transmission lines rather than distribution lines, the same principles apply to the latter.

The study and intelligent use of this book should enable Engineer officers to design and erect safe lines in the most economical way with the minimum of trouble, and do away with the element of guesswork which has undoubtedly been present in many existing installations.

The chapter on iron and concrete poles, especially in regard to the design of the latter, should be of the greatest value to those Engineer officers situated in countries where the ravages of the white ant preclude the use of wooden poles, and where climatic conditions are also troublesome to iron and steel poles, or where transportation difficulties necessitate the manufacture of poles on the site.

R.W.C.

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MAGAZINES.

REVUE MILITAIRE FRANÇAISE.

(*October*, 1929.)—Lieut.-Col. Desmazes completes "*De Liao-Yang à Moukden*" in this number. Throughout this series of articles the story has not been obscured by intricate details of forces and orders, and the writer indicates clearly the reasons for the Japanese success. This instalment is devoted to the Battle of Mukden, which was by far the most decisive victory of the Japanese and in fact ended the War. Curiously enough, both Oyama and Kuropatkin decided to attack on practically the same day, but as soon as Kuropatkin saw the Japanese advance, he immediately gave up his own plans and conformed to the operations of his enemy. Throughout the battle, "combined units," drawn from various formations, were formed by the Russians, so that the natural confusion of a big battle was made indescribably worse. By the end of the battle the Japanese had reached the main railway line from the north-west and the Russian forces only just escaped an overwhelming disaster. As Col. Desmazes points out, the failure of the Russians might have been turned to good account, if the lessons had been properly applied, but the so-called brilliant cavalry leaders, Rennenkampf and Samsonoff, were largely responsible for the terrible disaster of Tannenberg in 1914.

In continuing "*Motorisation des engins de combat rapproché*," Général Chédeville discusses the various sizes of tanks proposed by what he calls the "new school." He points out that every tank, whether small or large, has its drawbacks. If a tank is provided with a comparatively short gun, perfectly satisfactory for use against infantry, this gun will not have the muzzle velocity necessary to fight other tanks. The provision of a high-velocity gun means a bigger tank. By similar reasoning, he comes to the conclusion that tanks will go through the same stages as aircraft and will develop into a number of different designs for different purposes, *i.e.*, reconnaissance, attack, pursuit, and so on.

Lieut.-Col. X . . . begins "*Un cas concret de tactique générale*" in this number. He takes as situation that of the 9th Corps on the right of Von Klück's 1st Army, at the battle of the Marne, when Von Klück decided to strike at and outflank, if possible, the French forces coming up from Paris on his West. The article is too detailed to be interesting to the casual reader, but the various considerations affecting the plans of the different commanders are clearly set out.

"*L'armée soviétique*," by Capitaine Malraison, is an important article on the present-day Red Army. He describes the terms of service, more onerous than in any other nation, together with the sub-division of the Red Army into active and territorial formations. The Ogpu, numbering

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100,000 and organized as the secret police of the Communist Party, are then described, and we must remember that the actual Communists are a comparatively small part of the Russian people. Finally, Capitaine Malraison discusses the efforts of the Soviet Government to militarize the Russian people, and gives his views on the efficiency of the Army. Although considerable progress has been made in its training, the writer does not consider the Army in any way up to the standard of a modern force. We must always remember that a Russian Army has hardly ever been successful *out of Russia*, and it is unlikely that the present Army is an exception to the rule.

(*November*, 1929.)—Général Vanbremeersch has a complete article, entitled "*La reprise de Bab-Hocéîne et d'Oued-Hamrine*," in this number. He describes a minor operation in Morocco of September, 1925, where the French retook certain positions which they had lost previously. The article may be of value for careful study, but the map is so bad that the operations are most difficult to follow. For the general reader there is little interest. In conclusion, the writer discusses the best composition of troops in this mountainous country and points out that the use of tanks and artillery on wheels is frequently rather a nuisance than a help on account of the difficult conditions.

Général Chédeville completes "*Motorisation des engins de combat rapproché*" in this number. After describing his views on the big tank for breaking through a hostile position, the reconnaissance tank and the types of vehicle required for the transport of infantry (where he suggests that the reconnaissance tank must have tracks, not wheels), he then gives his conclusions. Briefly, his opinion is that the infantry will require three types of tank, viz., a co-operating tank (*char d'accompagnement*) of about 17 tons, carrying a shortened 75-mm. gun, a lighter reconnaissance tank of considerable speed, and a pursuit tank (*char de chasse*) also of about 17 tons but armed with a small high-velocity gun. Then he suggests a "land cruiser" of 30 to 35 tons, protected against direct hits from field artillery, and, finally, a break-through tank (*char de rupture*), weighing 70 tons. It does seem that, even if the writer's reasons are correct, it will be impossible for so many tanks to be produced in large numbers, and one wonders how many bridges will carry a 70-ton tank.

The conclusion of Lieut.-Col. X . . . 's "*Un cas concret de tactique générale*," reads like a glorified staff college scheme, complete with detailed comments by the instructor. One almost misses the use of red ink. The article is either worth reading carefully, together with the map attached, or not at all, but at the end the writer explains the principles brought out even in a comparatively simple exercise of this kind. These principles bear a very close resemblance, as indeed they should, to our own principles of war as laid down in *F.S.R.*, Vol. II.

Commandant Tournoux begins an interesting article, entitled "*Les fortifications permanentes belges et françaises*," in this number. Although the role of these fortresses has generally been belittled by the Allied writers, Commandant Tournoux points out that the existence of Liége, Namur and Antwerp, together with the series of French fortresses, had a considerable effect on both the plans and the operations of the Germans

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in 1914. He quotes largely from the writings of various German generals and it will be seen that the menace of the fortresses is taken seriously by them. In fact, Von Bülow, commanding the German 2nd Army, was probably affected throughout the German advance by the original difficulty of capturing Liége. In this instalment the Belgian fortresses and the Schlieffen plan, based on the French fortresses, are considered.

"*L'armée italienne en* 1929," by Commandant Conquet, is a detailed description of the present-day Italian Army. As the writer points out, the development of the Army under Mussolini has not been blazoned abroad like his political and economic works. We must realize, however, that the Italian Army is progressing and that Mussolini has undoubtedly produced a feeling of good military morale, which did not exist after the Great War. In this instalment, details are given of the organization of the Italian division and of the number of men available. In a country whose birthrate is increasing and where the land frontiers are protected by mountains, it is natural for infantry to preponderate throughout the Army.

(*December*, 1929.)—"*En relisant Clausewitz*," by Général Lemoine, is the first of a series of articles designed to explain the general tendency of thought of the great German military writer. Général Lemoine points out that most of his books are really unfinished and that it is left to the reader to decide exactly what Clausewitz thought when he wrote his books on war. In this instalment, the writer discusses Clausewitz' attitude in face of the principal difficulties affecting a commander in war, viz., the multiplicity of factors, their variability, the difficulty of appreciating them, the danger of outside abstractions, and the character of the principles involved. The reasoning of the instalment, however, seems rather academic and there is a tendency towards platitudes, a tendency very difficult to avoid in an article of this description.

"*Le renseignement et la manœuvre*," by Capitaine Mousset, describes an example of the common fault of failure to reconnoitre before an advance. The example taken is from the 19th Corps of Von Hausen's 3rd German Army which marched into a deployed French position early in September, 1914, shortly before the battle of the Marne. The action is described clearly without too much detail, but we must remember that, although "time spent in reconnaissance is seldom wasted," it is remarkable how often commanders fail to reconnoitre, and to interpret reports, before setting their troops in movement.

Commandant Tournoux completes "*Les fortifications belges et françaises*" in this number. He quotes continually the German writers regarding all the French fortresses, and it is quite clear that they had a very considerable effect on the German advance, and might have had still more effect if they had been brought up to date. It was, in fact, on account of the French fortress system that the German attack was launched through Belgium, and it was probably the violation of Belgian neutrality which caused the final defeat of the Germans. Commandant Tournoux considers that the day of the fortress is by no means over and it certainly does seem that by the construction of modern fortresses, the French can do a great deal to protect their north-eastern frontier.

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"*L'artillerie du 21e corps d'armée le 26 Septembre*, 1918," by Lieut.-Col. Aublet, describes the organization and action of the artillery in one of the great successful blows of the autumn of 1918. Full details are given, but one cannot help feeling that the conditions described are unlikely to occur again, as the author indeed says at the end of the article. The enormous mass of artillery and the careful preparations required are familiar to most officers who served in France during the Great War.

Commandant Conquet completes "*L'armée italienne en* 1929" in this number. The instalment deals with the air force, colonial troops, carabinieri and militia. The air force has expanded from 80 machines in 1922 to 1,200 in 1929, an indication of the result of Mussolini's determination to have efficient armed forces. The militia is, perhaps, the most interesting part of the Italian forces, as it is a new Fascist organization. Men are trained from their youth up and a considerable proportion enlisted in militia "legions," who will take their place with the regular army in the field. The whole article is well worth reading by anyone who wishes to find out how Italy has advanced militarily, as well as politically, during the last seven years.

H.A.J.P.

VOENNO-INGINERNA BIBLIOTICA

(*Bulgaria, Military Engineers' Journal*).

This journal was founded after the Revolution of June 9th, 1923. General Volkoff, an engineer and artillery officer, who at the time was i/c. Map Section, G.S., at the War Office, had largely organized the *coup d'etat*, and became War Minister. His accession to the virtual command of the Army gave some impetus to technical and scientific study.

The journal is quite well got up, and appears every two months in issues of about 160 pages, costing 40 levas (1s. 4d.) each number.

Its object, as declared on the back page, is to "Spread a knowledge "of military engineering in the Army and in society, and thus to assist "the Government in the preparation of the country for national defence." Of the 6–12 articles in each issue, not more than two are indigenous—the remainder being translations from engineering and general military publications in other countries.

The Bulgarian contributions are, judged by the standards of France or our own country, of a very elementary character.

(*January–February*, 1929).—1. In a rather lengthy article entitled "Radiotelegraphy," Colonel T. Petrescu examines the uses and role of short-wave length R/T stations in the field, and pleads for the registration, for military use in emergency, of amateur owners of wireless sets. In support of this he quotes a proclamation or appeal, issued in the Soviet publication, *Radio Vcem* ("Radio for all") of 1.4.1928, which is not without interest at the present moment. The appeal runs:—"Convinced that another war is possible—nay, inevitable—we are "obliged to put all our radio-technical resources at the disposal of the "Army. At last the question of putting owners of private sets ('radio-

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" amateurs ') at the disposal of the State is capable of solution. The " militarization of all radio-amateurs—that is to say, their military " instruction and the registration of their instruments, and the formation " of the amateurs themselves into groups of specialists—is, therefore, a " problem which demands immediate attention. Let our watchword be, " ' *Short-wave length owners! Prepare yourselves and your stations for* " ' *the coming war! Organized cadres of militarized wireless amateurs* " ' *are the best answer to Chamberlain!* ' "

2. In " Roads or Railways? " Engineer Ivan Dankof goes at some length into the statistics of other countries concerning road and rail transport.

He considers that as far as Bulgaria is concerned, the answer to this question is " Roads *and* Railways." In some official quarters, he says, it is held that railways have had their day, and that any money available for their further development would be better spent on roads. This, he contends, is a great mistake—the railway system is still very far from adequate even for the needs of the country at the present, without taking into account increasing population and developing industry. Railway transport is still much cheaper than road—costing about 5-6 centimes (gold) per ton-kilometre. (Road rate is not mentioned.)

(*May-June*, 1929, Jubilee number, 1879-1929). 1. " Survey of the development and services of the Bulgarian Engineers " (on the occasion of the fiftieth anniversary of their formation). Major Kotseff reviews the development of the engineers in Bulgaria from the formation of one pioneer company and one instructional company under Russian officers in 1878, up till the present time.

By the outbreak of the Balkan War, 1912, the engineers had grown to 9 Pioneer Bns., each consisting of 2 " Pioneer " and one " Bridging and Telegraph " Company.

The performance of the engineers in this war left much to be desired, owing, the author thinks, to inadequate specialized training and to too small a cadre in peace time. He tactfully makes an exception in favour of Captain (now General) Volkoff (who was Minister of War at the time the article was written), whose handling of a pioneer company at Lule Burgas was described as brilliant.

On mobilization for the World War in 1915, 10 Pioneer Battalions—one per division—of the same composition as in the Balkan War—were raised. These were increased by additional Bridging and Telegraph Companies as material became available from Germany.

In describing the immediately post-war period (1919), the author mentions one interesting item. He says the Inspector of Engineers at the time of demobilization introduced an organization which it was proposed to adopt " had we been victorious." This consisted of 1 Pioneer Battalion per division (eight in all), each battalion consisting of 2 Pioneer Companies, one telegraph and one bridging company. But this was premature. By the Treaty of Neuilly, " we were compelled " to reduce our engineer services to 3 Pioneer Battalions and 2 Cyclist " Battalions." It would be interesting to know to what extent the organization proposed " had we been victorious " underlies the paper organization adopted in deference to the Treaty of Neuilly. Also what

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part is really played by the cyclist battalions, which, incidentally, have very few bicycles.

2. In "Pontoon Companies from the Liberation (1877) till the present time," Major Popvontseff outlines the development of Pontoon Companies in the Bulgarian Army from its foundation, and then cites in detail the principal bridging operations undertaken during the World War, the greatest achievement apparently being the construction of a bridge 138 m. long over the Struma at Rupel, about the place where Gen. Sarrail had the railway bridge blown up on New Year's Day, 1916.

(*September–October*, 1928).—In an article entitled "Military Camouflage," but which deals exclusively with the interpretation of aerial photographs, Captain Velinoff gives some very useful though quite elementary instruction on this subject.

He shows some photographs of our (British) positions on the R. Struma in 1917, and demonstrates from these, and other photographs, how gun positions were given away by tracks to and from them; more especially when two or more tracks converge at a position. He emphasizes the necessity of limiting movement to one single route, and of obliterating wheel marks. On the Bulgarian side this was on occasions successfully done, by sprinkling brushwood and also ashes over the suspicious marks. The Bulgars seem to have got very satisfactory information about our positions from these photographs, which appear to be of about the same standard as our own at the time. The height from which reconnaissance was made is not stated.

A.C.B.N.

MILITAERWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*May–June*, 1929).—*Army and State.* On the plea that impressions gained by an individual help us to a truer picture than any other kind of historical record, Col. Heller makes a study of two historical reports hitherto unpublished, one by the Austrian Archduke Albrecht, addressed to the Emperor Franz Josef in August, 1866, shortly after the preliminary peace between Prussia and Austria had been concluded at Nikolsburg; and the other a report by the Duke of Würtemberg, an officer in the Austrian service, who visited the German troops before Paris early in 1871, giving a complete account of his impressions. The two reports might easily bear sub-titles, "The Causes of Defeat" and "The Causes of Victory" respectively, and are thus interesting enough to soldiers, even apart from their vividness, which is a charm that aids instruction.

The Campaign against Roumania, 1916 (*continued*). Lt.-Col. Kissling's lecture carries on the tale with the conquest of Walachia and the Dobruja, the occupation of Bucharest, and the pursuit to the Sereth-Danube line. The chief point that he brings out is the value of unity of command, claiming that it happily overcame all obstacles on the side where it existed, the Germans, Austro-Hungarians, Turks and Bulgarians being all under the command of the Emperor William, and that the lack thereof ruined the other side, the Roumanians and Russians. There were a great

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many other factors which contributed to success, as the author abundantly shows; and it is an exaggeration to attribute it all to unity of command, the importance of which is nevertheless not to be denied.

Lt.-Col. Kissling thinks that the entry of Roumania into the War, with an army inexperienced in war and badly led, and regarded by its Russian ally with mixed feelings, gave the Central Powers just that opportunity they so badly needed at that time, to restore the strategical balance. Otherwise the armies of the Central Powers, hemmed in and condemned to position-warfare on all fronts, might have collapsed even in 1916. The conquest of Roumania opened up to them wide territories, rich in resources.

Contributions to the History of Armoured Trains. The first suggestion of an armoured train emanated from a French naval officer, Montgéry, over a century ago. An armoured train appears to have been first used in Bohemia in 1848. Major-Gen. Kerchnaue follows the A.T. through the various campaigns, including the Egyptian war of 1882, the Soudan 1897, and the Boer war, to its use in all theatres of the Great War. Two excellent examples of A.T. action appear to be purposely omitted, as having recently appeared in *M.u.T.M.*, viz., in the Ukraine (*v. R.E. Journal*, March, 1929) and in Esthonia (*v. R.E. Journal*, December, 1929). Against this the good story is told of a German subaltern in the Herrero campaign, who, taking reinforcements up-country by ordinary train, was driven off by the enemy, took the train back, armoured it, and repairing the permanent way as he went, broke through and relieved the beleagured garrison. Subsequently, with the assistance of the navy (which has always played an important part in improvisations of this nature), with naval guns and personnel, he defended and kept the line open from Swakopmund to Windhoek, until reinforcements arrived from Germany.

F.A.I.

REVUE MILITAIRE SUISSE.

(1929. NOS. 7 TO 12 INCLUSIVE.)

Tactique et technique. The original article appears in No. 7 and is contributed by Capt. Joho; he briefly indicates therein some of the developments which have taken place in recent times in tactics owing to new inventions and discoveries. He points out that it is now impossible to deal with tactical problems in old-fashioned ways; technical factors have to-day acquired an immense importance, and, as the Great War has shown, play a formidable part in a battle.

The *savoir technique* is, in many respects, intimately bound up with the *pouvoir tactique*; the former forms an essential part of the foundation upon which the art of leadership should be built. Capt. Joho is of opinion that the *arme du génie* should, to a greater degree than has been the case hitherto, be considered as an *arme combinée*, in the same way, indeed, as are the artillery and the air force. In consequence, engineer units should only be placed under "the orders of the other arms" in exceptional cases, and only when missions of short duration have to be carried out.

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Les gros appareils de bombardement. The original article is contributed to No. 7 by Lieut. E. Naef; he furnishes particulars therein of certain types of bombing machine.

La guerre aéro-chimique et la défense anti-aérienne. Three further parts of the article under the foregoing title by M. S. de Stackelberg appear in Nos. 7, 8 and 9 of the *Revue*. Particulars are given in No. 7 of a portable type of electro-mechanical position-finder for use in connection with anti-aircraft artillery. It is stated that in the case of the Saint Chamond position-finder, the guns can be placed at a distance of 500 m. from the observation station; each such station can be used for controlling the fire of 4 guns employed in 2 sections, which can thus be located 1 km. apart—the individual guns of each section may be placed 50 m. apart. A few particulars are also given in this number of the *Revue* of certain types of anti-aircraft artillery.

Problems connected with fixed and permanent defences in relation to aerial warfare under conditions likely to prevail in the future are discussed in No. 8. M. de Stackelberg deals first with the subject of mobile anti-aircraft defence in relation to field warfare, and then states his views on the "future of fortresses and fortresses of the future." Problèms connected with the defence of towns are also touched upon in No. 8.

The air attacks on Paris during the Great War, and the lessons to be derived therefrom are dealt with in No. 9. Particulars are given of the German air-raids on Paris in 1918; a tabular statement is provided in which the numbers of German machines engaged in each raid, the numbers which succeeded in penetrating within the French fortified area, the numbers of bombs dropped and the numbers of German machines brought down are set out in detail.

M. de Stackelberg suggests that a belligerent acting on the defensive requires at least five times as many machines as those employed by an attacking force in order to make sure of beating off enemy machines. The results of the aerial warfare during the Great War, so far as the principal Continental Powers are concerned are tabulated; the following particulars may be of interest:—

Belligerent.	*Nos. of enemy machines brought down.*		*Ratio of (a) to (b)*
	(*a*) *By gun-fire.*	(*b*) *In aerial combat.*	
Germany ...	... 500 ...	... 2000 ...	... 1 : 4
France ...	... 1520 ...	... 6554 ...	... 1 : 4·3
Italy	... 129 ...	... 540 ...	... 1 : 4·2

M. de Stackelberg is of opinion that the foregoing statistics cannot be used as an argument against the efficacy of anti-aircraft artillery; it alone proves, he thinks, that France had gained supremacy in the air, and that her pilots dominated the situation. The evidence available indicates that, as in the case of terrestrial conflicts so also in the case of aerial conflicts, it is the waging of war in a downright offensive spirit which gives the greatest promise of a successful issue to a campaign. Consequently, it is essential that anti-aircraft artillery should always be in a position to seize the initiative and to carry out offensive operations

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so that it may dominate the aero-chemical arm while the assailants' formations are still distant from their objective; only in this way can the national territory be spared the ravages of a barbarous type of warfare.

De Vercingétorix au maréchal Foch. The original article is contributed by Col. F. Feyler to No. 8; it contains an interesting review of an important publication recently issued by the Librairie Larousse, *Histoire de l'armée française*, which has been compiled under the direction of Col. J. Revol, as editor.

Méthode de Combat. The original article is an anonymous contribution to No. 9; it deals with the tactical handling of artillery and the co-operation of this arm with the infantry.

Ce que vaut l'interdiction de la guerre chimique. The original article is contributed to No. 10 by M. de Stackelberg, who points out therein that the Protocol of 1925, which forbids the use of poison gases in warfare, has been signed by 18 out of the 50 members of the League of Nations; nevertheless, this does not by any means suggest that a stop has been put to the development of measures for the utilization of the chemical arm in warfare. On the contrary, research work in relation to this branch of warfare is being actively pursued in many countries; the directions in which this work is proceeding both in relation to the offensive and also the defensive aspects of chemical warfare are briefly set out and discussed in the original article.

L'avenir de l'aviation. The original article is contributed to No. 11 by M. de Stackelberg, who discusses the subject mainly from the point of view of possible future discoveries which will tend to render aerial machines less vulnerable to attack from anti-aircraft artillery, and which at the same time will make them more formidable weapons for bombing purposes.

Un débat sur les responsabilités de la guerre européenne. The original article is contributed to No. 11 by Col. Feyler, who deals therein with the hostile reception accorded in Germany to Vol. I of the French Diplomatic Correspondence, recently published by the Commission appointed to investigate matters bearing on the origin of the Great War. The subject is carefully examined by Col. Feyler, who refers to the propaganda which has been in progress in Germany since the termination of hostilities with a view to reversing the verdict on the question of Germany's responsibility for the outbreak of the European conflagration in 1914, as set out in the Treaty of Versailles. He points out that the popular agitation which has been going on in Germany on the subject is simply a political manœuvre, and, regrettable though it certainly is, this propaganda can serve no useful historical purpose; the facts which have been made public in the State papers now made available to all historians will provide the true answer to the question: who was responsible for starting the World War?

A dépense égale, la plus forte aviation fait la plus forte armée. The original article is contributed to No. 12 by Lieut. E. Naef; it contains what is really a plea for recognizing an air force as the real and chief arm for the defence of a State.

W.A.J.O'M.

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BULLETIN BELGE DES SCIENCES MILITAIRES.

(1929. TOME II.—NOS. 4 TO 6 INCLUSIVE.)

Les opérations de l'Armée belge—1914–1918. Events relating to a part of the period of stabilization, during which the Belgian Army held a portion of the Allied line along the Nieuport-Furnes Canal, are dealt with in the three numbers of the *Bulletin* under notice: the contents of No. 4 relate to the period May–Dec., 1915; those of No. 5 to the period Jan. 1st to June 5th, 1916; and those of No. 6 to the period June–Dec., 1916.

An account is given in No. 4 of the negotiations which took place between the Commander of the French XXXVI Corps and the Chief of the Belgian General Staff, in relation to the proposal made on Nov. 15th, 1915, by Joffre, that the part of the front near Steenstraat, then held by the French, should be handed over to the Belgians. A detailed description is also given in this number of the *Bulletin* of the manner in which the Belgian front was organized in the spring of 1915, and the measures taken to strengthen this part of the Entente line.

An appreciation of the situation, which was prepared by the Commander of the French XXXVI Corps, is given in No. 4; in it are set out the plans for meeting any attack which the Germans might launch against one or other of the sectors of the Entente front extending from the sea to Ypres. The text also appears in the same number of a letter from King Albert to the Commander of the French XXXVI Corps; it contains a criticism of the French proposals.

A general survey of the military situation during the first six months of 1916 is given in No. 5. The Germans had launched their great offensive against Verdun on Feb. 21st; only when the British and French troops moved to the attack on July 1st, and the Somme offensive began, was the enemy driven to assume a defensive attitude on the Western Front. During the first five months of the year no movement of any importance took place on the German Eastern Front. The Russians were not fit, after the heavy defeats of the previous year, to undertake further operations at this time; they were engaged in carrying out a reorganization of their Army, and thus gave the Germans a free hand to deal with the French at Verdun. On May 15th, the Austro-Hungarian Army launched its offensive in the Trentino against the Italians, but made only slight progress. In the Balkans, the Army of the Orient, created by the Entente Powers in Oct., 1915, grew steadily in strength; it was joined during the early part of 1916 by the Serbian Army, which had recovered from the effects of its retreat in the winter of 1915. During the first six months of 1916, the strength of the Serbian Army had been gradually raised to 300,000 men.

The dispositions of the Belgian forces during the period Jan. 1st to June 5th, 1916, are given in some detail in No. 5; a sketch map, showing the sub-divisions of the Belgian front, is included in this number of the *Bulletin*. The operations of the Belgian Army during this period are also briefly described therein, and a short review is given of the tactical developments of this period.

A review of the military situation during the latter half of 1916 is

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contained in No. 6. The Entente Powers had now assumed the offensive. The first of the grand attacks was launched by the Russians; Broussiloff advanced between the Pripet and the Roumanian frontier on June 4th, 1916, and broke through the enemy's front. To meet the situation thus created, the Central Empires were compelled to withdraw troops from the Western and Italian fronts. The Russian advance was not checked until Sept., 1916; by this time they had reconquered the Bukovina. The Franco-British offensive on the Somme continued until the middle of Nov., 1916; it compelled the Germans to abandon their operations against Verdun, where the French reoccupied an important part of the area which had been won at a very heavy cost by the Germans. The Italian Army had in June reconquered a part of the territory in the Trentino, lost by it during the previous month. At the beginning of August, the Italians launched an attack against the enemy's lines on the Isonzo; these operations continued for three months, and heavy losses were inflicted on the Austro-Hungarian forces, which were at the same time also feeling the heavy pressure of the Russian Army. On the Balkan front, the Army of the Orient was engaged in offensive operations during the period Sept.–Nov., 1916.

Although successes were obtained by the Entente Powers on the several fronts, and the situation became critical for the Central Powers, a decisive defeat of the latter was not secured. In the meantime, on Aug. 27th, 1916, Roumania declared war against Austria-Hungary and her Army invaded Hungary. Roumania's success was very temporary, and, contrary to all expectations, her entry into the conflict proved most unfortunate for the Entente Powers: it enabled the Central Empires to win an important victory towards the end of 1916. The moment now seemed opportune to the Central Powers for a move to negotiate a "German Peace"; it was made, but fortunately proved unsuccessful.

The proposal to extend the Belgian front, to which attention is called in an earlier part of this notice, is further dealt with in No. 6. The text of a Note, dated April 24th, 1916, in which Joffre outlines the role to be assigned to the Belgian Army is also published in this number of the *Bulletin*. The Belgian Army eventually took over the section of the line Steenstraat-Boesinghe. The dispositions of the Belgian divisions subsequent to this event are set out in some detail. The operations of the Belgian Army during this period, matters affecting the troops, and the further developments which took place in relation to tactics are also described in No. 6.

La tactique des renseignements. The final part of the article, by Col. Tasnier, under this title appears in No. 4; it deals in some detail with the following matters: the distribution of intelligence; its utilization; the external duties of officers of *2es Bureaux*; and the special features of the *2e Bureau* of a division. The duties and responsibilities of the intelligence officers of infantry regiments, and of artillery and of aviation formations are also discussed. In the concluding section of the article, Col. Tasnier sets out the manner in which instruction in intelligence duties should be carried out in peace-time in the case of the rank and file as well as of officers.

La survie d'un peuple. The 4th, 5th and final parts of the article, by

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Major Delvaux, under the foregoing title appear successively in the three numbers of the *Bulletin* under notice.

The retreat of the Serbians from the Danube to the Adriatic is dealt with in No. 4. Attacked at the end of Sept., 1915, by the Germans, Austro-Hungarians and Bulgars, abandoned by her Greek Ally, and insufficiently supported by the Entente Powers—owing to commitments on other fronts—Serbia was faced with annihilation. The Serbian Army of 230,000 men had to contend with an Austro-German Army of 350,000; further, Bulgaria had mobilized another 400,000 men. In the circumstances, no other course was open to the Serbian Army but to retreat rapidly towards the shores of the Adriatic across the fields of Kossovo; in doing so, it put up a stubborn fight with the portion of the Bulgarian Second Army encountered on its march. An interesting account is given in No. 4 of the operations connected with the Serbian retreat; eventually, 130,000 men, after having endured intense hardships, succeeded in making the passage of the inhospitable and almost impenetrable mountains of Albania.

The operations undertaken by Austrian and German submarines with a view to preventing supplies from France and Italy reaching the Serbians and the naval operations in the Adriatic are also described in No. 4.

The measures taken to reorganize the remnants of the Serbian Army and the arrangements made for its transfer to the Salonika front are dealt with in No. 5. The Entente Powers having decided that the remnants of the Serbian Army should, in the first instance, be transported to Corfu, a notification of this decision was sent to the Government at Athens accordingly; a French naval squadron appeared at Bizerta, and occupied Corfu on Jan. 11, 1916. The arrangements made for the transfer of the Serbians from the mainland to Corfu are fully described in No. 5; their withdrawal was covered by Italian troops sent to Durazzo and Valona for this purpose. On Feb. 22nd, 1916, the last Serbian soldier at Valona embarked for Corfu, and a Serbian Army of 120,000 men had by that date been collected on the island. However, a Serbian cavalry division—13,000 men and 10,000 horses—still remained in Albania and was not withdrawn until April, 1916.

The Serbian campaign gave rise to differences between the Enemy Powers; these are briefly touched upon in the original article. Matters relating to the administration by the enemy of the invaded territories, the steps taken at Corfu to assist the recuperation of the Serbian Army, the work of the "British Adriatic Mission," and the abortive negotiations which took place between the Entente Powers and the Athens Government in connection with the proposal to disembark the reconstituted Serbian Army at Patras, and to transport it by rail *via* Athens and Larissa to the neighbourhood of Ekaterini on the Aegean Coast, are fully discussed in No. 5.

The offensive operations on the Macedonian front during Sept., 1918, are dealt with in No. 6. In this number the article opens with a review of the events of 1915–1918, following the occupation of Belgrade by Austro-German troops in Oct., 1915, which was succeeded by the invasion of Serbia by the Bulgars on the 11th *idem*, and the disem-

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barkation on the 12th *idem* of Sarrail, the C.-in-C. of the French Army operating in Serbia, at Salonika.

Successful operations carried out in May, 1918, in the neighbourhood of the heights of Jarebitchina by the Greeks, supported by a French Colonial division, prepared the way for the offensive of the September following. At the latter date, Franchet d'Esperey was in command of the "Armée d'Orient," which was constituted as follows: 8 French divisions, 4 British divisions, 1 Italian division, 6 Serbian divisions and 9 Greek divisions (total: 28 divisions—600,000 men). Opposed to it was a Bulgar force grouped in 4 armies, consisting of 445,000 men and 1,270 guns, exclusive of the 3 Austrian divisions occupying the region W. and S.W. of Lake Ochrida. The successive operations which had to be carried out to break through the Bulgar front, and the manner in which they were conducted are described at some length in No. 6.

An armistice, bringing hostilities to an end on the Salonika front, was signed on Sept. 29th, 1918: the terms embodied in the document are stated in the original article.

La bataille d'Aubers, de Festubert et de Loos (1915). The original article is in two parts, which appear in Nos. 4 and 5; the account of these battles is based on the materials provided in Vol. IV of the British *Official History of the Great War.*

Étude des raids faits à Kippe par des troupes de la 1 D.I. dans la nuit du 18 au 19 Août, 1918. The original article is contributed to No. 6 by Capt. Daubechies; he sets out the objectives assigned to the troops detailed to carry out the raid; the character of the region in which it took place and the enemy's defensive arrangements; the plans on which the infantry attack and artillery action were based; the execution of the attack and the results obtained. He further furnishes comments on the operations and on the lessons to be learnt therefrom.

W.A.J.O'M.

HEERESTECHNIK.

(*April*, 1929).—*The Influence of the Technical Development of the Firearm on Infantry Tactics.* Having enunciated the principle that the foundation upon which tactical methods must be built up is weapon-effect, the author shows how the hand firearm has gradually improved to become eventually the chief weapon of the infantry, and traces how the fighting methods of the latter in the course of time have been modified and re-moulded in accordance with the increased effectiveness of the weapon. It follows from his initial proposition that the best tactics is that method of fighting which permits the utmost use of the possibilities of the hand firearm.

The technical development of the firearm, hand or otherwise, has in general been carried out on the following lines:—The creation of a safe means of ignition, increased handiness, increase of rate of fire, increased accuracy, increase of range, flatter trajectory, improved state of a fire-preparedness, increase of effect on the target. These individual points have come sometimes more and sometimes less into the foregound. It has happened in the course of time that technics "faint, but pursuing,"

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has done no more than strive to keep pace with the soldier's urgent demands. At other times, again, technics has made progress not desired by the soldier, but which has on the contrary filled him with uneasiness and mistrust, so that, especially after long periods of peace, powerful opposition has arisen against the introduction of improvements.

The saying is trite that the invention of gunpowder transformed warfare. Looking back through history it is not difficult to see the truth of this statement, but the transformation took place so slowly that it may well have passed unnoticed while it was in progress. It covers a period of three and a half centuries, from the invention of gunpowder, popularly ascribed to the monk, Berthold Schwarz, in 1320, until the first order was given for every infantry soldier in his army to be equipped with a firearm, by the Elector of Brandenburg, Frederick III, in 1689.

This example was followed by other States, and the pike, as an alternative to the firearm, disappeared from the great armies of Europe. The invention of the bayonet, however, re-introduced the pike in another form, when, as an addition to the firearm, it gained sufficient repute for the Russian General Suvaroff to say a hundred years later, " The bullet is a fool, only the bayonet is wise."

The infantry firearm, starting with a weapon made at Liége in 1414, capable of being served and fired by one man, but incapable of being aimed, owing to its heavy support and forged-on spike for taking the recoil, is then traced by the author through its various stages of match-lock, wheel-lock, and flint-lock.

The drill for loading and firing is similarly traced from the two hundred motions laid down as necessary for these purposes by Maurice of Orange in his " Manual," until it was reduced by Frederick the Great to twenty-three motions : and the changes in tactics are followed to 1806, when the better drilled Prussians were forced by the French armies of the Revolution to abandon their idea that " skirmishing brings out the natural coward in the soldier and kills the spirit of the offensive."—(*To be continued.*)

The Berlin Automobile Exhibition, 1928. After an interval of seventeen years there has taken place again in Berlin a large international automobile exhibition of cars, lorries and motor-cycles, which both in extent and in number of exhibitors has created a record among international automobile exhibitions. By the number of firms exhibiting there were—in cars, 24 German to 38 foreign ; in lorries, 25 German to 9 foreign ; and in motor-cycles, 34 to 13. These figures are taken as proving that in the two latter classes Germany's leading position is so well assured that foreigners do not find it worth while to compete. The increase in the total number of motor-vehicles in Germany in one year, viz., 29%, shows, however, that the country is still the best of markets for such goods.

The number of types of car shown per firm has risen from 1.7 to 2. This is looked upon as a bad sign, partly referable to unstable economic conditions in Europe. Salient points of interest were : that the light European two-seater, four and six-seater approximate more and more to American lines : that there is a great increase in high power eight-cylinder engines : a promising further development of clutches and gears ;

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and that the flexible axle and the worm-wheel drive have made their appearance.

As regards engine-details, the light metal piston is firmly established, being found in 90% of the car-exhibits. A notable example is the Bohnalite, which has steel inlays, actually of Invar steel, possessing a very low co-efficient of expansion. This piston has made great headway, and is said to be installed already by two hundred firms.—(*To be continued*).

The Degree of Accuracy to be expected of Guns and Trench-Mortars, by Lt.-Gen. Baron Botzheim. The justification for an article of this nature appears in the first few lines, in which the author points out the surprising fact that generally in judging of the capabilities of guns and trench-mortars their degree of accuracy in hitting—the opposite of strewing—is but seldom consciously taken into account. What may contribute much to this neglect is that in military literature the tables giving the most important particulars of guns, etc., contain no mention of this point, and that it is almost entirely missing from the *Training Regulations* and from tactical handbooks. And yet the question of accuracy forms an essential factor in determining how far different kinds of guns, especially at longer ranges and against small targets, are actually capable of carrying out the different kinds of tasks allotted to them, with the ammunition at their disposal and within the appointed time. There is also the further question of whether in certain cases the "shorts" to which one's own infantry are exposed occur owing to normal strewing.

There is nothing new to the older generation of Garrison Artillery officer about such questions. He has always been accustomed to work them out. The calculations of percentages of hits, and consequently the amount of ammunition required against small targets, were twenty years ago the Garrison Artilleryman's daily bread; and special significance was accordingly attached to the factor "accuracy" as compared with other factors, *e.g.*, rate of fire, ranging, etc.

The increasing introduction of heavy field howitzers into mobile warfare also emphasized the value of the latter factors, since these heavy pieces could generally attain their object, *e.g.*, against field artillery in the open, better with a certain amount of dispersion than by accurate shooting at a point.

For the Field Artilleryman, firing chiefly shrapnel, there was before the war little occasion to concern himself greatly with the dispersion which would occur at the longest ranges; but during the war, ballistic questions were forced upon the artillery by the large amount of unobserved shooting according to plan, and the accuracy necessary for a good barrage.

In all countries there is now taken as a starting-point a mean dispersion in length of about 1%, and a mean dispersion in breadth of 1 to 2 per thousand of the range. With increasing calibres the former decreases to ½% and less. The maximum dispersion to be expected is 4 times the mean dispersion, but under war conditions, with worn barrels and inferior ammunition, such as is manufactured in war-time, the dispersion may rise to 2 or even 3 times this distance. Theoretical examples are then given and the figures are compared with the actual

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dispersions of the present-day guns and trench-mortars of the German Army.

Of the 1916 field-gun the dispersions in length and breadth respectively should be :—

At 5 km., 50 m. and 5 m.
At 10 km., 50 m. and 10 m.
At 14 km., 150 m.

Actually at 6 to 7 km., there is a length dispersion of 50 to 60 m. At 10 km. the length dispersion has risen to 110 m. and the breadth dispersion to 30 metres. Even the strewing at a range of 2 to 4 km., viz., 20 to 30 m. in length and 1 to 3 metres in breadth, shows that, allowing exact registration, it will take between 10 and 20 rounds to get a hit on a small target like an m.g. nest, single gun, dugout, trench-mortar or bridge. Theoretically the 7.7 cm. gun takes 100 to 150 rounds to get a direct hit on a target 5 m. x 2 m. at 6 to 7 km. : actually, as the above figures show, it is much worse. At 10 km., where observation is no longer possible, effective fire against small targets is hardly attainable. An increase of range of this gun to 14 km., which has been proposed and which is certainly constructively possible, would render effective fire in the above sense more illusory still.

With larger guns so much damage can be done by splinters that we are no longer justified in demanding a direct hit. The author sums up the various types as follows : The 1916 field-gun, accuracy as shown above is less than might be expected theoretically ; the 1916 light field howitzer, though not heavier than the 1916 field-gun, is ballistically very good ; the 1917 10 cm. gun is more accurate than the 7.7 cm. at all ranges, its dispersion at medium ranges being not greater than standard ; the long heavy field-howitzer, 1913, dispersions are greater than with the light field-howitzer, although the opposite should be the case ; the 1916 15 cm. Krupp gun, built to outrange enemy guns firing 17 to 18 km., is a distinct type of overloaded gun with bad strewing and quick barrel-wear ; the light mortar, accurate at all ranges, so that with quite sufficient mobility and fire-preparedness it was rightly known in war as a " wonder of technics."—(*To be continued.*)

The Piezo-electric Effect and its use in Wireless (*continued*). To be of practical use for wireless purposes a crystal must satisfy three conditions : (1) It must possess the piezo-electric effect. (2) Its period of natural oscillation must be calculable in advance. (3) It must have a practically utilizable decrement of damping.

Since in present practice only quartz crystals are used, the article deals only with such. As explained in the last number, a quartz crystal in order to possess piezo-electric effect has to be cut in a particular manner.

The natural frequency of a quartz slip can be calculated immediately with sufficient accuracy from the formula

$$f = \frac{v}{2l}$$

where v represents the velocity of propagation in quartz, being the number of cm. travelled per second, viz., 545,000 ; and l (or d) is the

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length (or depth) of the crystal in cm., depending upon whether the oscillations to be measured are longitudinal, or at right angles to the longitudinal axis.

The wave-length of a sender, etc., which can be controlled by a piece of quartz of given length (or thickness), can be most simply calculated from

$$\lambda \text{ (metres)} = 1.1 \times 10^3 \times l \text{ (cm.)}.$$

The range of waves for which pieces of quartz can be prepared is very great, since for longer waves the length, and for shorter waves the breadth of the crystal can be used. For thickness oscillations the limits in size of the crystal are from about 9 mm. to .2 mm., corresponding to wave-lengths of 1,000 metres and 20 metres respectively. These, then, are the limits of waves to be measured by quartz through its oscillations at right angles to a longitudinal axis.

For shorter waves still, either a harmonic must be used or a suitable longer wave is produced by quartz control and reduced by frequency transformation to the desired smaller value. These proceedings are of great practical significance, since it is precisely with short-wave senders that the exact adjustment to and maintenance of the sending wave are of the utmost importance.

The author then gives us certain notes on the preparation of quartz-crystals, and of Cady's two methods of using them for wave measurement.—(*To be concluded.*)

(*May*, 1929).—*The light limbered Telephone-wagon.* This wagon started issue to the troops last spring, following three earlier trial vehicles of 1926, 1927 and 1928, but differing in construction and equipment essentially both from the then existing service article and from the trial vehicles. These notes on the new wagon are accordingly considered necessary.

The following conditions were considered essential for the construction :—

1. To replace the small sprung telephone-wagon 1905 by a light limbered vehicle with its centre of gravity as low as possible so as to improve cross-country powers.
2. To solve the question of a Universal type Telephone-wagon.
3. To standardize with the body of the small wireless-wagon.
4. To arrange the equipment more accessibly and more purposefully.

On account of repeated complaints from the troops wood has been abolished from the superstructure and its place has been taken by sheet steel. It has been proved with this material that fears of the equipment suffering through overheating from the sun are not justified. The doors have been made dust- and water-tight.

Light metal has been used wherever possible, viz., Lautal, hard sheet aluminium, and Silumin.

The distribution of equipment is office and instruments on the limber, line stores on the rear wagon.

The brake-lever, as in artillery vehicles, is on the saddle side of the rear wagon.

The axle is dropped to get the weight low and to be of the same pattern

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as that of the wireless wagon, which has its axle dropped on account of the engine.

The wagon is drawn in the infantry by a pair of horses, in the cavalry by six, and in the other arms by four. It carries four men, two on the limber and two on back seats on the rear wagon. Its weight empty is 740 kilos, loaded but without crew 1,240 kilos.

A provisional list of stores was issued in May.

The Influence of the Technical Development of the Firearm on Infantry Tactics (continued). This instalment covers the period 1806–1866.

The eighteenth century, in which the idea of mass-fire had been dominant, produced no essential improvement. As regards the care of the firearm mass-fire had been directly detrimental, since all that was required of the weapon was that it should shoot, and how it shot was considered of small importance. A very small percentage of hits was reckoned with, estimated at one hit to fifty shots fired.

The nineteenth century, however, from the end of the Napoleonic wars was a period of continuous development, slow at first but very rapid towards the end. Napoleon himself, the artilleryman, had done nothing for the infantry weapon. The unreliability of the flint-lock was great, and often led to fighting with the butt. What brought the first progress was an improved method of ignition. The period itself is known as the " scientific " period, and not without justification, since it was scientific discoveries which created the possibility of further development. In 1786 potassium chlorate was discovered by Berthollet, and in 1799 fulminate of mercury by Howard. The two substances were used for firearms by the Scotsman, Forsyth, in 1807; and in 1819 a successful percussion-cap was made. The old mechanical arrangements for ignition were quickly driven from the field by the new " chemical lock," for its superiority was enormous. It had one twentieth of the number of missfires of the flint-lock, was twenty times as accurate, and permitted a slightly higher rate of fire. All the military nations went over to percussion by converting their flint-locks.

Weapon-technics were also striving to utilize the long-known advantages in accuracy and range of rifling also for the universal army-weapon. Such a rifle was expensive, wore out rapidly, got leaded up, and was very slow to load, so that the rate of fire fell to less than one-half. The problem of the army weapon of precision was eventually solved by the French captain, Minié, who inserted a small iron cup in the base of the bullet, which allowed the gases to pass through and press the soft lead walls of the bullet outwards into the rifling. Again all nations re-armed.

Whereas chemical ignition, though a great step forward, was not revolutionary, the introduction of the rifle opened the way to great tactical changes, owing to reduction of calibre and great increase of range of effective fire, viz., loose formations and open-order fighting, the line of skirmishers, decentralization of command, the utilization of cover, etc.

Still the rate of fire had not increased; it had even diminished. A hundred years earlier one had striven to increase the rate of fire. Now in many an army the principle of overwhelming the enemy by volume of fire was ignored, and it was believed that the same object could be attained by greater range and greater accuracy.

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Only Prussia took a whole step forward by introducing the breech-loader. In spite of all resistance, this rapid-firing device carried the day. Military circles indeed resisted stoutly, the danger of running out of ammunition being conjured up, as again later, before the introduction of the magazine-rifle and of the machine-gun—and now of the automatic-rifle.

It took sixteen years from the recommendation of the Proof Commission in 1839, who had even gone so far as to call it "a great gift of Providence," before the Prussian Army was equipped throughout with the needle-gun, and eleven years more before it "formally surprised the military world by its success on the battlefields of Bohemia."—(*To be continued.*)

The Berlin Automobile Exhibition, 1928 (*continued*). Battery-ignition has increased to a very great extent, only 32% of the vehicles shown still having magneto-ignition. Considering its extreme reliability magneto-ignition is unwillingly given up, but battery-ignition has made rapid headway owing to its cheapness.

Carburettors have had to accommodate themselves to the demand for maximum starting acceleration. Thus the new Zenith carburettor has essentially new features, including a small petrol pump connected with the throttle-lever, and thus giving a spurt of petrol out of the acceleration-jet, which ensures sudden powerful engine-acceleration.

The very neat appearance of modern engines with flanged-on gear-box is shown by photographs of the 4.6 litre 8-cylinder 80 H.P. Daimler-Benz, and 2.5 litre 6-cylinder 50 H.P. Wanderer.

Exhibited only as an engine was the U Double-piston two-cycle engine of Zoller, of which two excellent photographs were shown in *Heerestechnik* (Dec., 1929) after the Paris Exhibition. The object of these two-cycle engines is to produce something highly elastic like a steam-engine, so as partly, and perhaps later, entirely to do away with gears. Meanwhile they must be looked upon as being in the trial stage.

Special mention must be made of three American (Cadillac, Lincoln, La Salle) 8-cylinder engines in V form, on account of compactness and smooth working, of great promise for future increases of power and length.

Practically all modern cars have engine and gears together, although three years ago only 75% were so built. Plate-coupling, now in 90% of all vehicles, has contributed to this change.

Dry multiple-plate clutches are gaining on the dry single plate which the majority possess.

That with increasing engine-size the engine itself takes up a portion of the elasticity and power of accommodation to differing resistances is shown most clearly by the great increase in three-speed gears, now as many as 60%.

As revolutions have increased very much lately it was natural to call upon clutch and gears to share in the work of gaining increased elasticity. Two improvements on these lines, the N.U.G. Presto and the Erdelen automatic-clutches are then described with diagrams.—(*To be concluded*).

The Diversion of Industry on to War-work. A tendencious article full of indignation against the French Yellow Press, which is accused of

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constantly repeating statements to the effect that Germany, owing to the rapid development of its industry since the War, would "in the shortest time" be able to equip a new German Army and to maintain it in the Field. These statements are said to be among the favourite reasons for France's refusal to disarm, and it is claimed that this article proves them to be both untrue and opposed to common-sense. The article produces some of the difficulties of conversion, but is naturally unable to prove anything, unless it be the indignation of the writer. That such a diversion of industry on to war-work must take place the writer is obliged to admit: what makes him angry is that the Jingo Press abroad should pretend that it is an easy matter. He points out various reasons why the diversion of German industry to war-work would be more difficult now than in 1914:—

(1) Less peace-time production of war-material, owing to (*a*) smaller army, (*b*) no foreign armies now supplied, as was the case up to 1914.
(2) Recent legislation concerning labour has made mass-production much more difficult.
(3) There is a great lack of capital in private hands, so that from the first enterprise and undertakings would be thrown upon the State.
(4) Greater electrification has made greater vulnerability, so that in many places reserves of power would have to be provided.

In these respects it is claimed that all other industrial nations are far better off than Germany. Against them only one point is produced, viz.: increased standardization and rationalization have made it possible to make a better use of unskilled labour.

Who is to assess the comparative values of this point and the other four? The Chauvinists are of course wrong if they make out that the diversion can be made in Germany or in any other country easily or in a very short time. They would be right if they confined themselves to saying it will be done in every country in the shortest possible time.

The Degree of Accuracy to be expected of Guns and Trench-mortars (*concluded*). The light trench-mortar's dispersion from 200 to 800 metres' range is in length 10 to 35 metres, and in breadth 1 to 3 metres. It is thus reasonably accurate against small targets at these ranges. Above 900 metres' range and with high-angle fire at all ranges there is no possibility of shooting at small targets without a disproportionate expenditure of ammunition, although splinter- and moral-effect remain. But, 4–5% dispersion in length and 1% dispersion in breadth cannot be denied, and in face of the theoretical possibilities it must be admitted that the light trench-mortar is ballistically of absolutely small value—primarily accounted for by its short barrel and muzzle-loading.

Lamentable as this fact is, it is necessary to have the point clear so as to counteract erroneous views as to the results to be expected, and consequent nature of employment.

Taking next the medium trench-mortar, if its accuracy at short ranges can be considered just sufficient, in all else it resembles the light T.M. and

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its ballistic performance must accordingly, from the theoretical standpoint, be ranked as absolutely of minor value. Its chief effect and performance thus lie, not in its accuracy, which is only to a certain extent sufficient against small targets at the short ranges which were usual in trench-warfare, but in its greal moral and destructive splinter and air-pressure effects against living targets.

Against this, however, it cannot be sufficiently emphasized that it is only the destruction of the hostile heavy weapons which finally makes the way clear for our own infantry, and must therefore be striven for. The crew of the hostile heavy weapon can generally be replaced immediately, while the weapon itself cannot.

There follows a table of dispersions in length of the field-guns, howitzers and mortars already discussed, comparing them with the corresponding weapons of 25 to 30 years ago, from ranges of 1 to 10 km., as far as these apply.

These tables show at a glance a regular and all-round deterioration in accuracy. The older weapons had on the other hand less fire-preparedness, a lower rate of fire, and shorter ranges; but smaller weights and entirely sufficient mobility.

After this revelation the author feels that he must console. "It may, therefore, be taken as certain that, when the present work of systematic investigation of the factors affecting the accuracy of guns and T.M.s, especially at the tactically important longer ranges, is finished, a real improvement in ballistic performance will be attained." He detracts somewhat from the certainty by adding "provided that the troops, the designer, and the manufacturer hold firmly to the fact that accuracy is of paramount importance."

Practical hints are then given for bringing home to the troops and to leaders the importance of a correct appreciation of the accuracy factor.

The Piezo-electric Effect and its use in Wireless (continued). Describes Giebe and Scheibe's practical and most useful wave-measurer, which utilizes the light-phenomena appearing in a quartz-crystal when resonance occurs. The existence of a state of resonance is thus established, and the measurements thus made are accurate to 10^{-4} of the frequency.

To tune a sender it is usual to place three of these quartz-cells in parallel with the variable condenser of the closed oscillating circuit, one at the desired frequency, and the other two at frequencies differing .1 to .2% above and below respectively.

The disadvantage of all quartz wave-measurers is that there must be a quartz-cell for every wave to be measured, or preferably even a set of three, as just indicated.

Besides for wave-measuring, which is their most important and widespread use in wireless, crystals have also other uses, viz., for control of senders, and for tuning the received wave in receivers.

Their method of employment in sender-control is at once understood when one considers the crystal as replaced by a closed oscillating circuit. Such a way of regarding it is justified, since when resonance occurs the crystal behaves like a closed oscillating circuit.

Especially with short-wave senders it is usual to use an H.F. choke

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parallel to the crystal, for increasing the energy oscillating in the grid circuit by damping H.F. disturbance.

Because of the limit of thinness of the crystal, wave-lengths below 20 metres can only be controlled by quartz-crystals when the frequency of the latter's wave has undergone transformation. This is done, for example, by the short-wave sender at Nauen.

In reception the quartz-crystal is exclusively used for tuning. The extreme accuracy it gives is essential for short-wave reception.

In this case the *direct* piezo-electric effect is used, the crystal being on a tail, with one pole only connected to the grid-circuit, and the other disconnected. When resonance occurs crackling is heard in the telephone, and the crystal is then switched off.

The new All-Metal Dirigible. A short description is given of this American airship, which is chiefly remarkable for its external hull being made of Duralumin corrugated sheeting strips, and its method of propulsion, viz., steam-turbines with ordinary gas and oil as fuel.

A new type of Anti-Aircraft Machine-gun. Shows a photograph of four machine-guns lying side by side on a common mounting, machinery-driven, and said to fire 2,000 rounds a minute and to have a range of 3 miles.

(*June*, 1929).—*The Influence of the Technical Development of the Fire-arm on Infantry Tactics* (*continued*). After the rapid fire of the breech-loader had won a signal success for the Prussians over the Austrians in 1866, all military nations re-armed with the breech-loader. This was done either by conversion of their muzzle-loaders, or by introducing a new weapon; which latter case gave them the advantage of making a material reduction in calibre, to 11.5 mm., and less. Among the nations which adopted the second course were the French with the Chassepot. But the introduction of a new weapon, however superior in itself, does not guarantee any real superiority in battle until:—

(1) The troops have got to know the new weapon, and to recognize wherein its superiority lies.
(2) Appropriate tactical methods have been devised,
(3) Training has been such as to ensure complete exploitation.

The French with their small-calibre Chassepot had the ballistically superior weapon, but, for lack of the foregoing, achieved no more with it than to cause casualties to the Germans at ranges which came as a surprise to both parties. The war of 1870–71 proved as surely the superiority of the small-calibre rifle, as that of 1866 had proved that of the breech-loader, only obscured by the fact that in the later campaign victory rested, for entirely sufficient other reasons, with the side possessing the ballistically inferior weapon.

The nations found themselves compelled to re-arm, and this re-armament gave them the opportunity of introducing the great improvement of the metal cartridge-case. The new weapons, amongst which were the 1871 Mauser and the Bavarian Werder, had reached a pitch of excellence, which should have brought about a development in tactics. This development took place only to a small extent, or hardly at all.

The Russo-Turkish war, eight years later, showed how little had been

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learnt from the lessons of the Franco-German war. It produced, however, a new weapon. The Turkish infantry used at Plevna, besides their good Martini-Henris, the Winchester carbines of their cavalry, who were condemned to inactivity. The magazine-rifle, which had already appeared in several forms, and which had even been introduced into one army—the Swiss—in 1869, thus made its entry into war.—(*To be concluded.*)

F.A.I.

CORRESPONDENCE.

NEW ZEALAND NEWS.

THE Officer Commanding the Southern Depot Corps of New Zealand Engineers has kindly forwarded the photograph reproduced, together with the accompanying letter :—

King Edward Barracks,
Christchurch,
11th Nov., 1929.

The Editor, *R.E. Journal.*

SIR,

I am enclosing herewith a photo showing the training carried out by this Unit on a recent half-day parade (three hours).

It will be noted that full equipment for the assault bridge for this gap was not available and that the service trestle bridge was not completed. You will also note that petrol tins only are available in N.Z. for assault bridging.

In addition to the work shown in the photograph, remaining sections had erected on this day a swinging derrick and some 50 yds. of double apron fence.

This work is a normal programme for one half-day.

I would like to add that this photograph was taken without the Unit being warned, hence the rather untidy look of the odd stores, etc.

It is, however, sent to you not for criticism, but to show you what sort of work is carried out by the Sappers in New Zealand. A higher standard of work is of course reached at the annual Camp.

Yours faithfully,

J. W. DOW, *Major, N.Z.E.,*
Commanding Southern Depot
Corps of N.Z. Engineers.

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Engineer Training.

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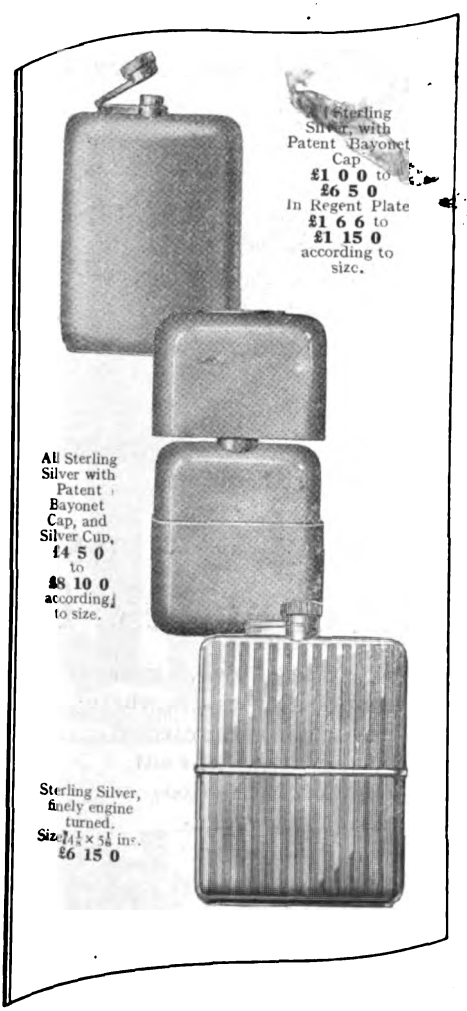
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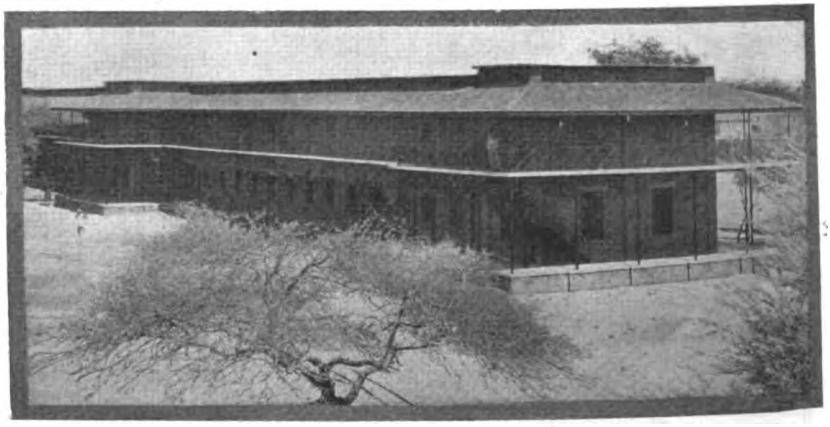

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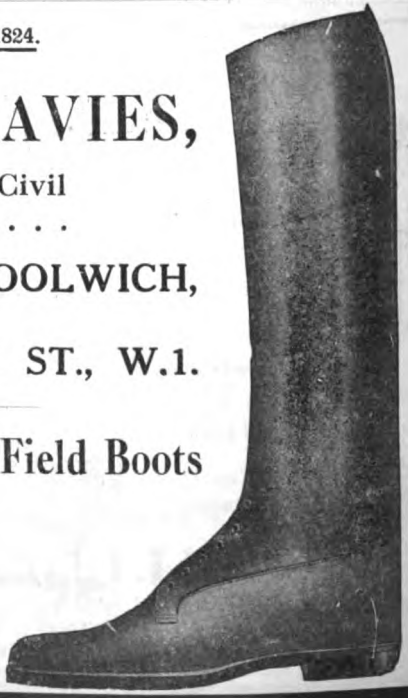

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THE NATIVE PRINCES OF INDIA.

A Lecture delivered by PROFESSOR L. F. RUSHBROOK WILLIAMS, C.B.E., *at the S.M.E., Chatham, on Thursday, 27th March,* 1930.

THE subject with which I propose to detain you for a few moments to-night is one of great political interest at this moment. Last autumn the importance of the Indian States was, perhaps for the first time, officially recognized in the correspondence exchanged between the Prime Minister and Sir John Simon. Sir John Simon said, in practically so many words, that in endeavouring to lay down the line of the future policy of Great Britain towards British India, he found himself at every turn brought up against the problem of the Indian States. That being so, he informed the Prime Minister that he desired to extend his investigations to the relations existing between the Indian States and British India. One of my objects in addressing you to-night is to make you realize why it was that Sir John Simon was brought to that conclusion and why it is now that the problem of the Indian States demands close and fixed attention.

In presenting the subject to an audience of this kind, it is hardly necessary for me to go into elementary details, but generally speaking, few people in this country realize that England does not rule India. The total area of what we call the Indian Empire, leaving Burma aside, is 1,500,000 square miles. Of that, we only rule 900,000 square miles. The remaining 600,000 square miles is not British territory at all. It is the territory of the Indian States. Inside that territory there live people who are not, as the British Indians are, our fellow subjects. Inside that territory the King's Government does not rule. Parliament has no vestige of control over anything that goes on inside that 600,000 square miles, and the people who inhabit it are the subjects of their own sovereigns, who are in subordinate alliance with the King.

A glance at the map of India will show the importance from a strategic point of view of the Indian States. It is possible to go almost from Kashmir to Cape Comorin, and almost from Karachi to Calcutta without touching more than a few miles of British territory. The native States lie in great blocks across the main lines of communication, and that is one of the reasons which, from a military point of view, makes the attitude of those States towards the Empire a matter of very great importance.

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In order to enable you to see the picture a little more clearly, I want to take you back some way into the past. I do not mean to emulate the example of an Oxford professor, who may or may not have been a colleague of my own, who announced a course of lectures on the French Revolution. He was a gentleman who was notoriously thorough and at the end of the second term, a colleague asked him how far he had got. He said, "I am doing very nicely. I have just completed the building of the third pyramid." But in order that we may realize what the Indian States mean to us, it is necessary that I should give you briefly some kind of information as to what they have meant to empires in the past, because India has extraordinary continuity of tradition, and if we look back into the history of that country, their recorded history, we sometimes get very useful guidance as to what is likely to happen in the present and in the near future.

We are the latest of a very long series of empires in India and all the empires previous to our own have crumbled. If you will bear with me, I should like to give you, very briefly, a clue to this process. The previous empires of India have been marked by one characteristic; this is to say, they have been founded by the process of invasion from the West and from the North-West. Races and dynasties from the cooler and more temperate regions which lie to the North and West of India have made their way to the plains of Hindustan, have established their military supremacy by force of arms, and have ruled the country. But as time went on, these successive races and dynasties found themselves brought up against the fundamental problem of the climatic influences of India. There always has been in India a tendency to assimilation. The people of the country have tended to assimilate to themselves and to obliterate the characteristic and distinctive marks of any civilization with which they have been brought into contact. Race after race has found itself threatened with virtual extinction by absorption, while the climatic influence has operated to weaken the vigour, both physical, mental and moral, of peoples accustomed to living under more temperate conditions.

The problem with which each empire before ours has been confronted has been simply this. How could the ruling race maintain unbroken the line of communication with the cooler country from which they came, so that they could fill the gaps in their fighting-line, administrative as well as military, and thus repair the ravages of the climate? Every empire before our own failed to solve that problem, for the simple reason that they depended upon land communications. No empire which attempted to rule Hindustan could long be successful, or has ever been successful, after it had lost military control of Afghanistan, and for reasons which will be familiar to many members of my audience it has not been found

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physically possible for any empire, even our own, to maintain effective control of Afghanistan for long. Therefore, in the case of previous Indian Empires, they have been confronted always with the dilemma that, if they wished to maintain their position in India, they had to maintain unbroken a long land line of communication; otherwise they could not replace their skilled administrators and generals, of which the climate had taken toll.

I know no more interesting example of that process than the series of Court paintings relating to particular families under the Great Mogul. When Babur came to India in 1526, and conquered the country, he introduced the fashion of Court portrait painting. Some of his noble families can be traced roughly from 1526 to 1710 or 1712, and it is extraordinary to notice the changes which accompany the appearance of the people. When these generals and administrators first came to India, you see them big, ruddy men, with high riding boots, whiskers and beards, carrying enormous swords—altogether very vigorous men. A generation goes by and you will see them turned into slim, elegant people, with heavily embroidered and brocaded coats, and a court rapier by their side. Another generation goes by, and then you see them clad in transparent muslin and holding a rose. That was the kind of alteration effected by the Indian climate on people who were not able to maintain their land communications with the cooler lands from which they came. We are more fortunate because our communication depends on the sea only, and from that point of view we are something new in the history of the Empires of India.

Having given you this brief clue to the history of the rise and fall of Empires in India, I want now to turn to the main subject of the lecture. All these empires have been of the same type; they have been very much of the nature of a loose federation, ruled from the top by a military power. An invader comes down and establishes military supremacy, but he does not rule the country as we understand it. He takes tribute from existing kingdoms and he insists on their rendering military service, and refuses to allow them to combine against himself. Occasionally he finds it necessary to destroy some of them, but the fact remains that the typical Empire in India—and to a large extent even our own—has represented the domination of superior military force over a large number of pre-existing units, semi-independent units. The history of the decaying empires in India before our own time has been simply this: Owing to the climatic influences, which I have sketched so roughly, the ruling power gradually fails to exercise the same kind of control, military and administrative, as it started with; the semi-independent units then raise their heads again, throw off the yoke and become completely independent, and so they remain, with a good deal of bickering and fighting among themselves, until the next invader comes down,

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depresses them again, exacts tribute, insists on military service and establishes himself as an empire.

The point, as you will doubtless have seen, to which I am leading is this: What we call the Indian States to-day, are the representatives of a system which is not merely older than our own Empire, but older than the empires of which we have any previous record in Indian history. You may say, if you like to use the simile, that the Indian States, the small semi-autonomous kingdoms, have always been the bricks out of which the fabric of successive empires has been built. Sometimes you get a brick broken, sometimes one is pulverized to dust, sometimes a brick is divided into several fragments, but broadly speaking, throughout the past history of India, you can discern something like the same bricks.

How did we build our Empire in India? Did we build it out of those bricks like our predecessors? To a very large extent, yes, because if from one point of view the creation of our Indian Empire depended upon our supremacy at sea, from the other point of view, it depended very largely upon our creation of an elaborate network of alliances and engagements with the existing Indian States.

When the first employees of the East India Company came to establish their factories on the coasts of India, it was not to the Great Mogul that they looked for permission. It was to the local Indian sovereigns. At first, as you know, they were far from possessing any intention of interfering with the politics of the country, and it was only the combination of disorder in the country and rivalry with the French which finally drove us into it.

It is interesting, and indeed sometimes pathetic, to read some of the early correspondence which was exchanged, let us say, from the middle of the 17th century onwards, between the Company's employees at Madras and Bombay and the Company's directors at home. The Company's directors kept on emphasizing the point that their servants in India were there to trade, and not to mix in politics. Why, it was asked, should they need forts and armaments? Why did they start recruiting Indians, forming them into companies and using them to garrison their small forts? And the answer was always this, although the words may have varied: "We are compelled to adopt this course and policy unless our honourable masters will send to India such as are stick-free and shot-free, and such as can digest poison." In other words, it was the fact that the strength of the Mughal Empire was breaking down at the time when we first came into the political arena, which compelled us to pursue the policy of standing up for ourselves, and we pursued it just exactly as any other Indian State pursued it. That is to say, in the first instance, being weak, we made treaties with the local sovereigns; then, in order to secure the validity of those treaties, we tried to get them ratified by the Mughal. After Clive's adventures in Bengal,

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we obtained from the Mughal himself the grant of the revenue collection in Bengal on payment of a heavy annual tribute. Then, as the Mughal Emperor and his administration got weaker and weaker, we did precisely what everybody else had done from time immemorial; we repudiated that tribute and said we proposed to stand on our own rights; and the year 1773, when Warren Hastings declined any longer to pay tribute to the Mogul Empire, marked the real beginning of our terrestrial power in India and put us on the same footing as the other Indian States. Hence it is that, from the historical point of view, our Empire in India is just an example, which might be paralleled in other times, of the gradual advance of one Indian State to a position of dominance and paramount control. We started as the smallest and weakest of all the Indian States. We gradually made our way up, through inferiority and subordination to equality and supremacy; but it is interesting to notice that as recently, comparatively speaking, as the year 1829, it was still customary for our Viceroy to address the Nizam of Hyderabad in the terms used by an inferior person to a superior. That was a relic of the old days, when our power was infinitely weaker than that of any other Indian State.

This process of growth, with which I will not detain you in any detail, affords an extraordinarily interesting study, to which I have no doubt some of you have already devoted attention, but there are two things which stand out. One is the fact that, while we relied to a very large extent upon our sea communications for the establishment and maintenance of our power, we relied to a scarcely less degree on an elaborate structure of treaties and alliances which we built up with the Indian States. In the latter days of the 18th century, we found a number of Indian States who were tired of the system by which they were continually fighting amongst themselves, and we found increasing numbers of them ready to enter into a kind of bargain, which suited them very well. We were afraid at that time of the influence in India of French intrigue. We were also desperately hard-up for money in order to carry on the political and administrative side of the Company's work. Accordingly, we proposed to some Indian States, and some Indian States proposed to us, a bargain something like this. An Indian State said, "I will give you complete control over my foreign policy. Your friends shall be my friends, your enemies shall be my enemies. Further, I will give you a sum of money which will enable you to maintain regiments to protect me." We, in return, said, "We will undertake to guarantee the perpetuation of your existence as a territorial unit and as a government, and so long as you remain faithful to your obligations, we will remain faithful to ours"; and a bargain was struck along those lines.

The result was that, roughly, by the year 1818, British power was

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supreme over something a little less than half of India. The larger part was still ruled by Indian States, but those Indian States were being bound to us by closer and closer connections as time went on. It was not, however, until just before the Mutiny that the territorial balance between British India and the Indian States was—owing to Lord Dalhousie's policy of annexation—definitely turned against the States. Up to the middle of the 19th century it was British India which was the smaller half and Indian India which was the larger half, of India. It is only since that time that the proportions have been reversed.

If we examine the opinions held by the Company's officers about the Indian States during the first half of the 19th century, we find that they regarded the fate of these units as being more or less settled. They thought of them as being awkward impediments to our humane, progressive and enlightened rule throughout India. Looking back over the course of the century, it seems pathetic to think that our early British administrators were convinced of the power of British interests, British thought, and British conceptions, to make their way in a triumphant march across the face of an ancient civilization like that in India; for we know now how slight is the impression which even a century of British rule has made upon many of the most fundamental thoughts, beliefs and creeds of the country. But the view which was held by early administrators was unduly optimistic. That being so, they regarded the Indian States as being an anachronism and an obstacle. They were convinced that in any event the day of the States was over, and that they had ceased to count in Indian politics. And yet when the Mutiny broke out, we suddenly found the States counted for a great deal. Indeed, as Lord Canning said, it was these patches of "native rule" which acted as a breakwater to the wave, which otherwise would have swept us away utterly.

After the Mutiny, of course, there was a revulsion of feeling in favour of the Indian States. People began to realize that they did count politically, and that they were not merely museum specimens destined to extinction, and further, that the rulers of these States set their plighted word to Britain above everything. But at the same time the policy we pursued towards these States seems to have been a little short-sighted. From early days, one of the cardinal principles of the dealings of the East India Company with the States had been to keep them rigidly apart, to prevent them having any communication one with the other except through us, and to treat them as isolated units. That, of course, was a tradition of the old days, in which we ourselves were merely one of a number of powers competing for mastery in India. Having obtained that mastery, we then decided that we could not afford to have the same process repeated against ourselves, and this policy—which we may call a

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policy of complete isolation—was responsible, during the first half of the 19th century, for a great deal of backwardness on the part of the States. When the rulers and the governments of different States who were, on the one hand, relieved of all responsibility for defending themselves, were also, on the other hand, prevented from getting together to discuss common interests, there was a tendency to sink into isolation and stagnation. After the Mutiny, that policy was not relaxed, because if the history of 1857–58 had shown that the States were loyal, from another point of view it had also shown that they were still formidable politically. Hence the policy of isolation was continued throughout the latter half of the 19th century. Still the rulers of the Indian States were not permitted to meet each other. Still the governments were not allowed to correspond. Still each individual State was kept at the end of a separate string, the other end of which was held by the Government of India. The consequence of this policy was that throughout the second half of the 19th century the States did not progress very much. They certainly did not progress relatively to British India.

The Government of British India, which had been established as a result of the Mutiny, was now trying to centralize, and was able to weld the enormous area of British India into something like an administrative unit. In that process it probably went too far, and the attempt to centralize administration in a country where historically administration has never been centralized may, incidentally, be at the root of some of the trouble at the present time. But the fact remains that while the Government of India was dealing with big schemes of development, railways, irrigation, canals, roads, and the like, throughout the great area of British India, the Indian States still remained comparatively poor and isolated. Nor was there very much chance, on account of their isolation, that their weight would tell politically, for this reason. When the Government of India Act of 1858 was passed, the Government of India, as we call it, which had succeeded the old East India Company, was given a dual task. It became the executive Government of British India, and it became the agent through which the Crown's relations with the Indian States were managed. No real distinction was made between the two tasks and, as you can readily understand, there was a tendency on the part of the Government of India—a very human and very natural tendency—to utilize its position of trust as Crown Agent for these States, to promote the due execution of its duties as the executive Government of British India.

The consequence was that, during the latter part of the 19th century, the Indian States became increasingly conscious that their interests and rights were becoming more and more subordinated to the interests and rights of British India. Our administrators in British India were directly responsible, through the Viceroy, the

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Secretary of State and Parliament, for promoting the welfare of British India in every right and just manner. What more natural than that, of the two responsibilities committed to their charge, the more direct should carry the day! The result was that before the new century had dawned, the Indian States were suffering in a variety of directions as compared with British India, and because they were isolated they were not in a position to make their voices felt politically.

During the time of Lord Curzon, that most masterful of Viceroys, the position of the Indian States was extremely depressed, and if at that time anybody had asked whether, in the event of a world war, the Indian States would count for anything, I think the answer would have been, as it was before the Mutiny, "No, naturally! How can they? They are too weak."

Fortunately, during the time of Lord Minto, a policy of greater confidence was adopted towards the Indian States, and they were encouraged by Lord Hardinge to feel that they were really partners in the Empire. I think the change came about through an increasing realization on the part of the administration in India of the growth of what we now call the Indian Nationalist Movement, which made us conscious of the fact that it was fatally easy for an English administrator, no matter how wise or enlightened, to make very dangerous mistakes. There was thus a tendency on the part of both those Viceroys—Lord Minto and Lord Hardinge—to consult the Princes about important matters; to seek their advice and to make them feel that they were no longer to be ignored; while, finally, as a conclusive proof of a changed attitude in regard to them, the Indian Princes were even encouraged to place their own troops into a condition of efficiency greater than that which had previously existed. They were encouraged to aspire to the association of those troops with the British Indian Army, and to earmark their best regiments for what were, until recently, called the Imperial Service Troops.

When the War broke out, as we all remember, the first people to respond in India were the Indian Princes, and the manner in which they placed their resources at the disposal of the Empire was not merely of the utmost value as an encouragement to British India, but also helped to steady the situation throughout many British possessions in the East. For there is this to be remembered about the position of the Indian Princes: In many cases they are the heads of clans which do not all live inside their own territories. You often find an Indian Prince is the hereditary chief of a clan which may people large areas of British India, and there is a tendency on the part of those clansmen, even the British Indian subjects, to look very much to their chief for guidance. A typical example has been the influence which has been exercised by the Maharajah of Patiala

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—who is head of the Sikhs—over the Sikhs who live in British India. The British Indian Sikhs have for some time been uneasy, and but for the influence he exercised in his personal capacity, a lot more trouble might have occurred than actually did occur.

This extra-territorial influence of the Indian Princes proved extraordinarily valuable during the War, because not only did they welcome recruiting parties into their territory, but they were able frequently to assist recruiting in British India by their example; and when you remember that within the territories of the Indian States live many of the most important fighting races of India, I think you will realize that the support of the States in the event of any grave imperial crisis is a very valuable one.

As a result of what the States did during the War, this age-old ban, which I call the policy of isolation, was removed, and from the year 1921 the Princes have met together every year at Delhi, in an institution called the Chamber of Princes—which I represent in London at the moment—which is presided over by the Viceroy. This Chamber of Princes has already been found very useful, because it is possible for the various rulers of the Indian States to get together to formulate common policy and speak with a united voice. The formal meetings of the Chamber are only held once a year and they rather approach in character, I fancy, the old Diet of the ancient Roman Empire, because every person who sits there is a sovereign or semi-sovereign in his own right, and the business naturally tends to be stiff and formal. But the Princes have got over that difficulty by the establishment of their own parallel machinery. For about a fortnight in Delhi every year, before the Chamber of Princes meets, the same Princes who, inside the Council Chamber, will constitute the Chamber of Princes, meet informally in a building of their own, and that is where their discussion takes place and the course of action is mapped out for the year, and where the decisions are taken which are subsequently put into formal shape by resolutions in the Chamber of Princes.

Within the last two years, the Chamber of Princes has opened its galleries to the press and the public, and the result of that has been a general recognition throughout India—and, perhaps I may say, an increasing recognition in England—of the fact that the Indian States count very much indeed in Indian politics.

Now, how are they likely to employ their influence? Well, I do not think there is very much room for ambiguity on that point. It is significant that last year, on the first occasion on which the press were admitted to the Chamber, one of the early resolutions dealt with the question of independence for India. The ideal of independence by cutting the painter between India and England had, at that time, already been mooted. The Indian Princes, who are well informed about the problems, particularly the

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problems, of British India, realized the danger, and they passed a resolution to the effect that, whilst they did not desire in any degree to interfere in the political problems of British India, they wanted British India to realize that if British India put forward any proposals to the Indian Princes, with the idea of arranging some kind of quasi-federation, or some arrangement for talking over problems which affected All-India in common, the Indian Princes could not consider any proposals which were not based upon a British connection. Again, when in December, Congress passed its resolution setting forth independence for India as its goal, the Indian Princes, individually and collectively, made their attitude once more perfectly clear. They said again, " So far as the ideal of independence is a matter affecting British India only, it is no concern of ours. That is a matter between Great Britain and British India; but in so far as independence is an ideal which is likely to affect the whole of India, we regard it as being inconsistent with the treaties which bind us to the Crown, and also contrary to the true interests of the country." The result of that has been that there are some symptoms now of a practical alliance between the Indian Princes and those parties in British India who are prepared to co-operate with Britain in working out a policy of Dominion status; and the Indian States are likely to supply a much-needed support for the more rational political element in British India.

That, briefly speaking, brings you up to the present moment. I think we have every reason to hope that with the Indian States playing the game, as they always have played it, and with the co-operating element in British India able to rely upon their support, it will be possible to arrange some kind of a working constitution for India. That the Indian States must come into that Constitution, as will be obvious from the sentences with which I started this lecture, has already been realized, and the Indian States are now admitted to be the third element of the Round-Table Conference, the other two being His Majesty's Government and British India.

I think, therefore, there is every reason to hope that, with the assistance of the Indian Princes and with their co-operation, India will still continue to be a real part of the British Commonwealth. One thing is clear and that is that perhaps the strongest of the links between Great Britain and India at the present moment is the Indian States. They take a personal pride in their devotion to the King. They are proud of the British connection still and, as they have shown in the past, so I think they will show in the future that no sacrifice is too great which, in their view, will enable this connection to be maintained.

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THE PROBLEM OF THE LAST 800 *YARDS.*

By BRIGADIER J. F. C. FULLER, C.B.E., D.S.O.

THE PROBLEM.

In brief, the problem is this: The offensive power of infantry is on the wane, because the defensive power of infantry is increasing. We cannot scrap our entire army and replace it by something new and more effective. How, then, are we going to modify our army to meet and partially overcome this difficulty?

TO-DAY we are an infantry army, thinking in terms of mechanization, and we are thinking of mechanization in terms of infantry, and as we recognize little or no change in the infantry idea our tactics have become muddled in the extreme.

What, then, is the infantry idea? Is it a constant or a mutable factor? History will show us that it is the latter, and that it is governed by the power of cavalry—the complementary arm.

When no cavalry were used, as amongst the Spartans, the infantry idea was an exceedingly simple one: A line of men advanced against a line of men, and unless it was long enough to overlap the opposing line, the battle was decided by pluck and muscular endurance. Tactics simply consisted in pushing pikes, of command there was little or none, and tactical skill was replaced by grit.

When cavalry is combined with infantry we see a vast change in the infantry idea. The assault is no longer carried out to push the enemy over and destroy him, but to hold him in a clinch, and so gain time for the cavalry to manœuvre round his flanks and towards his rear. From a smashing force infantry becomes a holding force; they pin down the opposing infantry, and the cavalry stick them in the back.

When infantry and cavalry oppose cavalry alone, the battle is frequently undecided, when they oppose infantry alone it is normally won at small cost; but when they are opposed by their like, under the best generals, the infantry hold and the cavalry hit, and battles are won more often by skill than by superiority of numbers. Such was the infantry idea until the advent of gunpowder.

At first, firearms made little difference, because of their crudeness. But as they became more perfect they simultaneously increased the power of infantry to resist infantry and cavalry, and so reduced the power of cavalry to attack infantry. The result was that gradually

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the cavalry idea of developing offensive mobility from the infantry holding attack changed; cavalry either sought cavalry to fight with, or they said to the infantry, "If you will give up holding and return to the assault, and break up the enemy's infantry, we will come forward and annihilate the fragments." The infantry agreed to this, and as the fire fight, even as late as the Napoleonic Wars, opened at only 100 paces' distance, a volley or two were fired, and a bayonet charge followed. The whole idea was to get home with the bayonet, the bullet was quite a secondary factor.

Until about 1860, infantry remained purely an assaulting arm, cavalry were impotent until the assault succeeded, and when muzzle-loading rifles replaced smooth-bore muskets the assault entered a rapid decline; not that riflemen could not hold an enemy, but because it was useless to hold him, for cavalry could no longer charge, that is, develop offensive mobility from the holding attack. During the American Civil War, seven out of every eight assaults failed, and so completely had the bullet defeated the bayonet, that infantry on the defence, especially when entrenched, could nearly always beat back a very superior frontal attack. So powerful had become the defensive that, in the 1870–71 War, not one single frontal attack by either Prussians or French succeeded. The assault was dead.

During this period in the history of tactics the central infantry problem was to resuscitate the assault. It was no longer a matter of rushing over a 100 yards, and then charging with the bayonet; but of methodically working forward over many hundreds of yards and then hoping to charge. It was entirely a problem of fire power, depending very largely on holding the enemy by artillery fire, and developing from this operation infantry mobility. In their own way, infantry were attempting what cavalry could no longer do. The rifle, however, soon shattered this imperfect theory. Increasing in range, the bullet forced the attacker to begin deploying at 1,000 yards, further than this it drove the field gun almost off the battlefield, until, at the beginning of the present century, the gunner had to adopt indirect laying and elaborate a complex system of observation and communication. The assault had long been dead, now the rifle attack began to expire. In the Russo-Japanese War, attacks covered days; in the World War, weeks. The attack then died, further the approach died, for, when once fronts were entrenched and wired, it was scarcely safe for the infantryman to raise his head above his parapet, and sheer suicide to move forward. All this is common knowledge. As the cavalryman of the 18th century said to the infantryman: "I can no longer charge until you have assaulted," the infantryman of the 20th century says to the gunner: "I can no longer assault until you have blown the enemy to pieces."

This, then, is the pivot of the present muddle—the assault. The

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assault has been dead since 1865, yet infantry will persist in revolving the whole of their battle tactics round this idea. Since 1870, the frontal assault has persistently failed for the simple reason that a rifleman on the defensive can shoot down a dozen or more riflemen sent forward to attack him. The holding power of the defensive is so strong to-day, and the range of rifle fire so great, that in open country it may be accepted as a fact that at 800 yards' distance from the defender the attack is brought to a standstill, and that from this distance it is not possible to do more than hold a fraction of the defender's force, because a few well-placed machine-guns will hold up an attacking brigade.

If the assault is to continue to be the infantry idea, then the problem is a perfectly clear one: infantry must be endowed with the power of advancing over these 800 yards, not in weeks but in minutes. But is this the best thing to do? Should not the tank, a piece of mobile armoured artillery, be contrasted with the infantry idea rather than absorbed by it? Obviously, in one respect the tank resembles cavalry, namely, in cross-country mobility. Less obviously, because we have forgotten the true role of cavalry; being armoured it can charge where cavalry can no longer exist. If equipped with lances it could do so far more effectively than cavalry. But no one would suggest so archaic a weapon, in spite of the fact that the majority of us still adhere to an equally archaic idea, namely, that the ultimate aim of infantry is to close with the bayonet.

Given tanks and infantry and equating their powers, we can, so I hope to prove, get back to the old cavalry-infantry idea, namely, infantry hold, cavalry hit.

The whole of this problem revolves round the last 800 yards. If infantry can be so equipped, or supported, that they can advance over this distance, or anyhow can move several hundred yards nearer to the enemy than they can to-day, they will force him to strengthen his defensive front; to draw on his reserves; to immobilize himself, and consequently they will hold him. They may threaten assault if you like, but their idea is not to disrupt him and risk being disrupted, but to pin him down, so that the tanks, the new cavalry, can gain time to manœuvre round his flanks and strike him in rear, and the rear is and has always been the decisive point.

What is to prevent this? The bullet? In 1914, bullets were mainly fired from rifles, and static warfare was the result. To-day, bullets are mainly fired from machine-guns; is warfare, then, likely to become less static? To-day, four to five times as many bullets would sweep over a battlefield than was the case in 1914, 1915 and 1916. Then we had thousands of guns to destroy rifles and machine-guns, to-day we have about 72 to each division; can it be contended that to defeat the bullet, and it is the bullet which is the whole crux

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of the last 800 yards, reliance can be placed on artillery? Obviously the answer is "No." What, then, can we do?

Remember the problem: that the infantry should be able to advance over the last 800 yards, and by constantly threatening the enemy, compel him to increase his defensive power by drawing on his reserves, and so force him to fix himself.

Remember the conditions which surround this problem: money is short in peace time; we can expect no drastic change; the best is enemy of the good; we must work from what we have and know.

How can we resuscitate the mobility of infantry? Strategically by motor transport, tactically by armour. Armour is the enemy of the bullet. A quarter of an inch of steel will keep out the rifle bullet, and half an inch the rifle armour-piercing bullet. Half an inch is what we want, it may not keep out the heavy bullet or the shell, but this is not the immediate problem. Let us first defeat the bullet, and when once this problem is solved, we can turn to the next.

We cannot armour all our infantry, but we know that we can obtain quite a good light tank. We have to-day in the British Army 16 machine-guns and 4 anti-tank weapons in each battalion. For an Oriental war, 20 machines per battalion are probably sufficient, and in a European war gold will flow like water, so an increase in this number need not perturb us. Now as to their use.

An attack is launched, and at 800 yards from the enemy it is halted by rifle and machine-gun fire. In place of calling on artillery, one to two miles in rear, to fire at a target which the infantry themselves can seldom see, out go the mechanized light infantry armoured scouts. All they know is the area from which fire is coming. They make towards it, hunting their enemy. If frontal fire is too strong they swing to a flank, they draw fire and deliver fire, then a novel thing happens. A fraction of the rifle line behind them moves forward from 800 to 700 yards' range, perhaps to 600 yards' range —a most astonishing innovation. The light tanks work up a hedge, round a hill; the enemy is pushing up reserves, but they head them off and climb its slope. Five minutes later a sight is seen which has not been witnessed for fifty years, some riflemen are on the hill and they have moved 800 yards in 20 minutes. They take the hill by assault? No. They merely occupy the hill, and begin enfilading the enemy on their right. They are heavily counter-attacked and driven back. Have they lost the day? No, they have begun to win it. They have forced the enemy to draw on his reserves, those forces which are an assurance against the unexpected and a security to his rear. Two or three more such engagements and the enemy will be fixed. All his troops will be tired, if not actually absorbed in the defence. Without reserves he cannot organize a retirement —he is fixed, anyhow for a time.

Have we solved the problem of the last 800 yards? Yes, we have

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solved it against an enemy unprovided with light tanks, and should an enemy possess them, then must the problem be reviewed and modified. But have we completed our task? No. We have only prepared the way. Holding must be followed by hitting, and never hit a man in front if you can hit him in the back.

Once the enemy is fixed, that is, his power to move is reduced from a fluid to a glutinous, if not a solid, state, the grand manœuvre can begin; but not before. To send armoured forces wandering into the blue is to ask for trouble, for the enemy may disperse. What is required is a concentrated target: therefore, he must be induced to put all his eggs into one basket.

What type of force do we want for this manœuvre? Not a cumbersome army of all arms, but a force somewhat like the old independent cavalry—light cavalry to find, heavy cavalry to hit, and a few guns to protect. Above all, we want a mobile force, and simplicity normally assists mobility.

Embussed infantry, accompanied by light tanks and mechanized artillery, would certainly be better than infantry on their feet, machine-guns in limbers and horse-drawn artillery; but to-day we possess far more suitable arms, namely, armoured cars, light tanks and medium tanks. We may sometimes require a mechanized bridging train, but we do not want field guns, or medium guns, or sappers, or infantry, or cavalry, because we want mobility, and because this force is going to strike at weakness and not at strength. This is what the old and rightly renowned cavalry did. They did not bump their heads against unbroken infantry—anti-cavalry forces; they avoided them. Why, then, should we expect their modern counterparts to assault anti-tank localities and weapons? True, they may meet them, but then they will avoid them; they will not assault or charge them, for such action is not at present their task. To-day we hear a great deal about the cavalry spirit, but this spirit will lead us into an excess of folly, unless we understand true cavalry action—to use mobility to develop offensive power against weakness and not against strength.

This force, the force for the grand manœuvre which should be the central idea of every battle plan, we see in embryo to-day in the projected Armoured Brigade; a force which, if we do not focus our tactics, will die in the womb, or be born a monster.

To-day we do not want a mechanized army, we want to solve the problem of the last 800 yards. In the future, we may want a mechanized army, and if we do it must grow out of our existing army, and not out of a fraction of it. We want to make good the problem of the last 800 yards, and to gain full benefit from it once we have solved it. Here, then, is the object of an armoured brigade—to crown our problem and so endow the tactical idea which underlies it with full power to govern our unimaginative army.

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Given an armoured brigade of one battalion of armoured cars, two battalions of light tanks, one battalion of medium tanks, and a properly organized supply column, and hinge this force to the existing army only slightly mechanized, then for the time being we have a superb army, because it is organized on a fundamentally sound tactical idea. Further still, it is so organized that it can grow to plan, namely, steadily increasing mechanization.

Before I end this paper, there are two points I should like to discuss, and they are the suitability of the medium tank, and the nature of the supply column in the armoured, or hitting, force.

Is the medium tank what the armoured brigade wants? Examine this brigade tactically. It is not purposely going to bump up against formidable opposition, that is, against anti-tank weapons. Its armoured cars will scour the country, and its light tanks can fall upon the rear of the enemy, and attack his line of communications, and his rear services. They may be met by their like, or by medium tanks, or they may want gun support. They, therefore, want some base to operate from, some supporting force which is more powerful than they are, and which is composed of anti-tank tanks.

The medium tank is too much a general purposes machine to fit this category. It may be an excellent divisional weapon—a weapon to support infantry, but it is not in my opinion a good anti-tank tank. What I suggest in its place is a low, fairly long, powerfully-engined machine, mounting one three-pounder gun, or a ·8-inch machine-gun, protected in a turret or by a roofless circular shield. If the latter, the shield might be so constructed that it can be closed to a semi-circle, and thus double the armour should anti-tank weapons be met with. This weapon would represent the artillery of the armoured brigade, designed as an anti-tank weapon, and not an anti-infantry weapon like the 18-pdr. field gun.

As regards the supply column, adequate and continuous supply is essential to the maintenance of the grand manœuvre. Frequently the armoured brigade will be miles away from its base, namely, the services in rear of the main army. Its line of communications will be an open one, and liable to be attacked by armoured cars and ordinary motor-cars. I suggest that, like the supply organization of the old independent cavalry, it should be equipped with two supply columns. One will go forward full, and the other will go back empty, and each will carry several days' supplies. These columns will require an escort of their own, an escort of armoured cars and light tanks and possibly also a battery of anti-tank tanks. With such an organization the brigade should seldom be in want.

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DEFENCE AGAINST GAS.

A Lecture delivered at the S.M.E., Chatham, on 28th November, 1929, *by* CAPT. D. DUNLOP, R.A.

I.—INTRODUCTORY.

IN these days of international agreements not to employ poisonous chemicals as a weapon of war, it is natural for many people to assume that there is little likelihood of encountering this weapon in the future. To anyone holding this view, I would point out two main reasons why we can never afford to relax our preparedness.

(*i*) Some nations are not signatories to these agreements and, in addition, the experience of the late War showed us only too clearly that pacts are liable to be broken by a nation seeking to gain the advantage over her adversaries.

(*ii*) Any nation, with a well-developed chemical industry, is equipped from the very outset of a campaign to use this weapon without sign of preparation, owing to the very close relation between peacetime chemicals and those required for war.

For example, chlorine, the basis of nearly all the more important war "gases," is an essential peacetime chemical. Phosgene, a deadly war gas, is largely used in the dye industry.

Throughout history, all new weapons of war have been regarded as barbarous and inhuman, and such is the attitude of the great majority towards "gas" to-day. In addition, mainly as a result of War propaganda against the Germans, the general public imagine it to be the most horrible weapon imaginable—they picture men permanently blinded, choking for breath and dying in agony; H.E. and bullets have been so long established that these people seem to have forgotten the appalling non-fatal injuries and maiming effects that these latter weapons can cause. If any weapon can be called humane, there can be little doubt as to the greater humanity of "gas," which causes no disfigurement and little or no after-effects to those who survive, and the mortality figure even among troops with poor gas training and discipline, is extremely low, as these figures show:—

American Army Casualty Statistics.

Total casualties (all causes).	*Deaths.*	*Deaths.*
258,338	46,519	25%
Total casualties (gas).	*Deaths.*	*Deaths.*
70,752	1,400	2%

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Our own mustard gas statistics are particularly striking :—

British Mustard Gas Casualties.

Mode of attack.	*Total casualties.*	*Total deaths.*	*Deaths per* 100 *casualties.*
Mustard gas period, July, 1917, to end of War	160,970	4,167	2·6

The corresponding percentage deaths from H.E. and bullets was 22 per cent.

It is owing to this proved superiority of mustard gas over all other war gases that I propose to devote my time this evening mainly to problems connected with it.

II.—Protection Against All Known War Gases Other Than Mustard Gas.

I must necessarily deal with this quite briefly.

The prevention of casualties from their effects is purely one of good training in the use of the respirator, good gas discipline and sound organization. If, on the other hand, these essentials have been neglected, then heavy casualties are bound to occur.

There may be occasions in the field when the weather conditions are such as to allow these gases to hang about in the atmosphere for a considerable time without dispersing. Under such circumstances, a commander may, if the tactical situation permits, move his men out of the area in order to avoid keeping them in their respirators. On the other hand, if the tactical situation does not so permit, then he can remain in the area with respirators adjusted for many hours, if necessary—provided, of course, his men have been accustomed and trained to wearing their respirators for long periods.

III.—Mustard Gas.

That the British Army alone had over 160,000 casualties from this gas during the last 15 months of the War, tends to aid and abet the alarmist views held about it in some quarters. It is a fact, however, that nearly 90 per cent. of these casualties could have been prevented by the wearing of the respirators then carried by all ranks. It was mainly due to a lack of knowledge of, and training in, the peculiarities and insidious nature of this gas that this great wastage of valuable men occurred.

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(*a*) *Characteristics.*

Now what are these special characteristics peculiar to mustard gas?

(i) It is very persistent, *i.e.*, at average temperatures the liquid vaporizes slowly.

(ii) Both in liquid and vapour form, it penetrates all ordinary clothing and affects all parts of the body with which it comes into contact.

(iii) The odour of it is not very strong, nor very unpleasant, nor has it any immediate irritant effect.

(iv) It has a delayed action, *i.e.*, it may be many hours before the effects show themselves.

(*b*) *Physiological Effects.*

The physiological effects may be summarized, as follows :—

(i) Inflammation of the eyes.

(ii) Erythema, or burning of the skin, which may be followed by blistering, especially in the moist parts of the body. These blisters normally take several weeks to heal.

(iii) Inflammation of the nose, throat, trachea and bronchi, followed by the development of secondary bronchitis or pneumonia.

The respirator, then, will give full protection to prevent all the above effects except (ii). To become a casualty in this way, a man must either come in contact with the actual liquid (directly on to his skin or through his clothing), or be exposed to the vapour for some considerable time. As regards the latter, it is difficult to lay down any hard and fast rule, but it is considered that an average man would have to be exposed for about half an hour, to the highest concentration of vapour ever likely to be met with in the field, to produce actual blistering in the more moist parts of the body some hours later. Under average conditions and concentrations, an exposure of several hours to vapour might fail to produce any blistering effect, although an erythema might result.

IV.—Possible Methods of Distribution of Mustard Gas in War.

Before dealing with mustard gas problems in the field, it is necessary for me to say a word or two about the possible means of releasing this gas in war.

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These are as follows :—

Forward Areas.

(*a*) *Artillery Shell.*

This was the only method employed in the late War. It has the advantage of not requiring any special organization or personnel.

The main disadvantages are (i) the small weight of chemical in each shell in proportion to total weight, *e.g.*, 4·5 in. Howitzer shell weighs 35 lb., only 4 lb. (approx.) of which is mustard gas, and roughly one-third of this is vaporized on the shell bursting, (ii) with the direct action instantaneous type of fuze, the liquid remaining after the shell bursts is largely confined to the crater, especially on soft ground.

(*b*) *" Water-Cart " Spray.*

This may be done from armoured cars or similar vehicles, or from trailers towed by them. It is suggested that 50-gallon tanks would be about the maximum capacity for one armoured car. This method might be employed to contaminate local areas or roads on a retirement.

(*c*) *Local Contamination Bombs.*

These might be bombs of various capacities which could be exploded electrically, or by delay action fuze, to contaminate local points, such as billets, destroyed bridgeheads, cross-roads, etc.

Back Areas.

(*a*) *Air Bomb.* (*b*) *Air Spray.*

Although my time is mainly to be employed in dealing with mustard gas problems in forward areas, the employment of this gas by an air force is so important that I feel bound to spend a few minutes in reviewing the possibilities and advantages peculiar to it.

Supply.

All gases to be used effectively in war must be put down in large quantities.

An air force can situate aerodromes in comparatively close proximity to supply bases, thus enabling them to obtain supplies in bulk far more easily than formations in actual fighting areas, which must necessarily be reached by much longer lines of communication. In mobile situations, this advantage must become very marked and may limit the use of gas to the air arm entirely.

Capacity.

Air bombs containing gas have not to withstand any shock of discharge, as in the case of a shell from a gun ; they can thus be

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constructed with a very thin wall, and contain a high weight of gas in proportion to total weight of bomb. The following figures speak for themselves :—

	Total weight.	*Weight of mustard gas.*
Air bomb	50 lb.	30 lb.
8-in. howitzer shell ..	200 lb.	28 lb.

As a result of this advantage, it is interesting to note that one squadron (10 machines) of modern twin-engined night-bombers, can carry a total weight of mustard gas equivalent to 3,500 4·5-in. howitzer shell (approx.).

Air Spray.

This method of distribution must be regarded as the most dangerous form in which mustard gas may be met with, as it is the one by which liquid mustard can be placed directly on to targets of personnel, as well as on ground or material. On release the spray is carried downwind, so spraying attacks to be effective under average weather conditions must be carried out from low heights and by pilots who are well practised and trained in the art.

If I may suggest it, these spraying attacks would be most effective on nights when there is no wind and roads are congested with troops on the move. Fast bombers of the " Fairey Fox " type could put down belts of liquid mustard over these columns, and flying at high speed would be difficult to hit before they disappeared into the darkness. Very large zones can be effectively covered in this way by a comparatively small quantity of liquid. It is interesting to note that the present procedure for embussed troops, when attacked with bombs by hostile aircraft, is to leave their conveyances and scatter to the sides of the road. If spraying was carried out, troops behaving in this way would expose themselves to the spray, whereas, if they remained inside, they would be protected from direct contact with the liquid.

Just exactly what is the most practical form of protection against this method of attack is difficult to say at present, but it is a problem that requires careful attention.

V.—Factors to be Considered in Studying Mustard Gas Problems in the Field.

I suggest that, as a general rule, a commander should appreciate mustard gas situations in the field under the following headings :—

(i) *Enemy Supply Facilities.*

Supply is the crux of the whole matter, where the employment of gas is concerned, owing to the large quantities required for effect.

To deny an area of ground, 100^x by 100^x, unless at risk of casualties, would require either 300 18-pdr. shells or 110 4·5-in. shells. An

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area, 1,000^{x} by 1,000^{x}, would thus require 30,000 18-pdr. or 11,000 4·5-in. howitzer shells (the equivalent of some 225 30-cwt. lorry loads). Such large areas are, therefore, entirely out of the question, except under stabilized conditions of warfare.

For spray areas, 1 gallon of liquid on an area, 7^{x} by 7^{x}, may be taken as a minimum to be effective: thus some 200 gallons would be required for an area 10,000 sq. yds., *i.e.*, 100^{x} by 100^{x}, or, 2,000^{x} by 5^{x}.

(*ii*) *Method of Release.*

With a spray area the liquid is evenly spread over the surface of the ground.

With a shell crater area it is almost entirely soaked up and contained in the crater itself.

Thus, in the former case, owing to the greater surface of liquid exposed to the atmosphere, persistence will be far less; but for a short time, at any rate, after being put down, there will be a greater risk of liquid contamination, which, in the latter case, would only be got by men lying or sitting in the craters.

(*iii*) *Quantity Liberated Per Unit Area.*

This explains itself—the more released on an area the greater will be the concentration of vapour. A reconnaissance officer would find it difficult to give a very accurate estimate, but in the case of a crater area, he could give an approximate idea of the number and type of shell per — sq. yds., and in the case of a spray area, whether contamination is heavy, medium or light.

(*iv*) *Time.*

It is important to estimate, roughly, how long an area has been contaminated when encountered. From the moment mustard gas is put down, except in frosty weather, it will be evaporating and persistence will be lessening.

(*v*) *Weather Conditions.*

The conditions prevailing from the time the gas was put down, and when encountered, govern entirely the effect it is likely to have on troops exposed to it. These conditions should be considered under the following headings:

(*a*) *Temperature.*—The length of time mustard gas will persist depends largely on this. Under 8°C. it will freeze, so although not dangerous at the time under these conditions, it will become so again when the temperature rises and melts it again.

On a hot summer's day (European), even a very heavily contaminated area is likely to be sufficiently safe to permit troops to traverse such an area within four hours after being put down. It must be remembered, though, that during that time, a very high concentration of vapour will be given off.

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(*b*) *Wind velocity.*—A high wind will quickly disperse any poisonous vapour, so its effect would be negligible under such conditions. On the other hand, until the liquid was all evaporated the vapour would become effective again if the wind dropped.

(*c*) *Wind direction.*—Troops should always be moved to the windward of a contaminated area if the tactical situation permits.

(*d*) *Rain.*—Heavy rain will rapidly wash liquid mustard into the ground, except on hard surfaces, such as tarred roads, in which case it will remove a large percentage of it from the surface into the gutters.

(*vi*) *Nature of Ground.*

(*a*) *Roads.*—On a tarred road, liquid will remain more on the surface and, therefore, give off a higher initial concentration than on an ordinary metalled road, which will absorb it to a greater degree.

(*b*) *Grassland.*—If sprayed, there would be, for a short time, at any rate, a greater risk of liquid contamination. This can, however, be avoided by well-trained troops, unless they are forced to lie down in the area.

(*c*) *Woods, houses, valleys, etc.*—In enclosed spaces, such as these, vapour will, of course, hang about in higher concentration than in the open.

(*vii*) *Duration and Nature of Exposure.*

If casualties are to be avoided this factor will require careful consideration.

Are men to be likely to risk contact with liquid or exposure to vapour? In the former case, in what way? In the latter, for how long?

Excluding air spray, the most common form of contact with liquid will be on the soles of the boots. Provided that these soles are in good condition the danger of penetration to the foot will be eliminated largely, provided that men continue to walk over uncontaminated road or downland after contact with the liquid.

As regards length of exposure to vapour to produce vesicant action on the skin, I have already given some approximate idea under "Physiological Effects." It will be realized from the facts indicated, that under normal weather conditions, men may be exposed for some considerable time to average vapour concentrations likely to be met in the field before risking casualties from blistering. In stabilized conditions, it will be necessary to arrange for frequent reliefs of troops called upon to occupy contaminated areas, in order to avoid casualties. The frequency will be determined by the degree of contamination and the weather conditions prevailing at the time.

(*viii*) *The Delayed Action of Mustard Gas.*

Even if conditions and length of exposure are such as to make casualties likely, a commander will be able to take into account the

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fact that his men will remain efficient fighting men for many hours afterwards, owing to this peculiar delayed action.

(*ix*) *Facilities Available for Decontamination.*

(*a*) *Of ground.*—Local areas can, if necessary, be rendered safe by applying such measures of decontamination as are most suitable. A commander will, therefore, require to know what materials are available to carry this out.

(*b*) *Of men and clothing.*—After long exposure to vapour, it is possible that the extent of casualties may be decreased by relieving troops and bringing them back for bathing and treatment of their clothing.

A commander will thus require to know what facilities, if any, are available for these purposes.

We have at present no organization to meet this, but I may mention that the American Army War Establishment provides for mobile bathing and decontamination units, and it is possible that we may have to be equipped with similar formations if occasion arises.

VI.—Practical Employment of Mustard Gas by an Infantry Brigade Retiring to a Prepared Defensive Position.

(*Map Scheme in Chatham Area.*)

Mustard gas available: 400 gallons and 2 contamination bombs.
Vehicles to put it down: 8 armoured cars with 50-gallon spraying trailers.

Lecturer's Notes.

This scheme was designed to bring out the following points:—

(1) Limited supply in the early stages of a campaign.

(2) Use restricted to employment by the retiring force using "water cart" spray or local contamination bombs. (Air weapons excluded.)

(3) The comparatively small areas that can be covered.

(4) The most effective use possible would be on roads in enclosed country, which enemy would require to use. (400 gallons might cover a maximum of 4,000 yards of road 5 yards wide.)

(5) Mustard should be put down (*a*) at the last possible moment to obtain full effect, (*b*) over 1,000 yards from forward defended localities for safety reasons in order to harass and to try and get casualties among the attacking force by the time their main attack develops.

(6) This gas must be looked on as a harassing agent and not a casualty producer against trained troops, unless it is definitely known that they have been pinned down in the contaminated area under favourable weather conditions.

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VII.—How Opposing Force Might Deal with the Situation Created in Foregoing Scheme. (Advance Guard.)

Local Contamination Bombs on Cross-Roads in Village.

Lecturer's Notes.

(1) Although Advance Guard would include Reconnaissance Party R.E., with A.G. Mounted Troops or Vanguard, a special Gas Reconnaissance Party would probably be provided, in addition, in order to relieve R.E. Party for their normal role. If any decontamination of local gas areas is required, however, it is suggested that R.E. Detachment, with the Vanguard (*F.S.R., Vol. II*, p. 65), would be called on to carry this out, as other A.G. units would not carry the necessary tools (shovels, etc.).

(2) On encountering this local contaminated area, officer in charge Gas Reconnaissance Party would send message back to O.C. Advance Guard, giving extent of contamination, post responsible man to warn all troops to adjust respirators in crossing and not to halt on the spot.

(3) Area covered with thick layer of earth or other material available by Detachment R.E. This is done as a precautionary measure and to obviate wearing of respirators in the neighbourhood.

(4) If this area is left untouched, there would be danger in two main ways: (*a*) to troops or units halted or occupying houses for some time immediately downwind of the area; (*b*) by men, whose boot soles had come in contact with liquid, entering shelters or billets shortly afterwards. In this case, the warmth inside may be sufficient to vaporize the small amount of liquid and pass unnoticed so that respirators are not worn—result, eye casualties.

Road in Enclosed Country Contaminated for a Length of 2,000 Yards by "Water Cart" Spray with no Alternative Route.

Points.

(1) Similar Gas Reconnaissance Party as in previous situation.

(2) In this case, there can be no question of decontamination.

(3) Reconnaissance officer should (*a*) send back message to O.C. Advance Guard to the effect that sprayed area on road from —— (map reference) has been encountered, that contamination appears to be gross, moderate or light, that he is reconnoitring the extent of it and will report again as soon as possible; (*b*) post responsible man to warn all troops to wear respirators and, as soon as the information is received, to inform all unit commanders of the extent of the area.

(4) It is not considered that reconnaissance should prove difficult in these circumstances because (*a*) in enclosed country a spraying

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vehicle would be confined to the road; (*b*) even if liquid cannot be distinctly seen by R.O., he can "test for gas" at frequent intervals to ascertain the extent of contamination.

(5) O.C. Advance Guard would appreciate situation under the headings previously given.

In this case, he will know that, as long as his troops are not halted or pinned down on the area, men will be exposed for under half an hour, as distance is only 2,000 yards. Thus, even if wind and weather conditions are exceptionally favourable for the use of mustard gas, he will not be likely to have any casualties from blistering effect of vapour; that is, of course, provided gas discipline is good and respirators are worn continuously until clear of the area.

(6) In all cases, other than Advance Guard, units would be responsible for their own gas reconnaissance.

VIII.—Special Problems for Royal Engineers.

(1) *Obstacles Erected Across Roadway and Splashed with Liquid Mustard Gas.*

If these require to be handled, I suggest throwing petrol over them and setting them alight in order to vaporize the liquid. Care should be taken that no one is immediately downwind of the point while this operation is taking place, as a high concentration of vapour will be given off.

(2) *Contaminated Mine Crater Across Road in a Defile.*

I understand that the R.E. procedure in this case would be either (*a*) to try and make a fresh track round, or (*b*) to make a causeway across, or (*c*) in certain situations to bridge the crater.

The main point is, however, that it would mean carrying out work round the crater for some little time. All that need be done in this case is to throw a layer of earth (or any similar material ready to hand) over the sides of the crater, in order to bottle up the liquid and prevent vapour escaping—work can then be carried out without respirators. If the roadway upwind of the crater has been contaminated, a layer of earth put over it for a short distance—say, 25 yards—would make it reasonably safe for work to be carried out for a long time provided respirators were worn.

(3) *Steel Bridge Blown Up and Contaminated with Mustard Gas.*

By what method would the bridge be contaminated by the enemy?

I suggest that it would be done by contamination bombs after the bridge had been blown up. If carried out before demolition, most of the "gas" would, in all probability, be removed or buried, and thus wasted.

In most cases, by the time R.E. were called upon to repair the

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bridge, I suggest that the liquid would not be visible on it—it would have partly evaporated and partly been absorbed into the paintwork or other material on which it had fallen. Personnel required for repair work would wear "gloves, anti-gas," and respirators as long as "gas" could be detected by smell.

In an extreme case, where R.E. are called on to carry out repairs immediately after demolition and contamination, a thorough hosing down by force-pumps wherever the liquid mustard can be seen, would improve the situation as it would wash off the gross contamination on the surface. If chloride of lime in sufficient quantity was available, an alternative method would be to scatter it all over the contaminated material. This will set up a violent chemical reaction and destroy all the surface mustard with which it comes in contact. Care must be taken in this case that no one is directly downwind of the spot, owing to the high concentration of vapour set up.

IX.—Conclusion.

To conclude, I wish to make it clear that, although some people hold grossly exaggerated views of the difficulties of encountering mustard gas situations, we can never hope to avoid a large percentage of casualties in the future, unless training in peace is designed to include a thorough instruction of all ranks in the characteristics and peculiar properties of this gas, in the wearing and care of the respirator, and in special measures of protection in the field.

Poisonous chemicals must not be regarded as something apart from other weapons and treated separately. They must be included in the picture as a whole, if our training for war is to be thorough.

Finally, let me take the opportunity of correcting the very common but erroneous impression that any knowledge of chemistry is needed for a thorough study and understanding of this weapon. When under fire from H.E. shell, we do not require to know that the chemical in the shell is tri-nitro-toluene or amatol, we are solely concerned with the effect of it on our bodies. Thus it is with poisonous chemicals—we do not need to know that mustard gas is dichlorethylsulphide: we want an understanding of its effects; and the only difference in the latter case, is that we are fortunate enough to be able, in the majority of cases, to take protective measures to avoid casualties, which is more difficult where high explosive shells are concerned!

Note.—Owing to the fact that the Scheme, referred to in Sections VI and VII, is one in current use at an Instructional Establishment, the map showing dispositions, etc., cannot be reproduced, nor can adequate reference be made to it. In view of this, the main points, which the Scheme was designed to illustrate, have been put down in the form shown, to avoid misunderstanding and for simplicity's sake.

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FIELD COMPANY TRAINING WITH OTHER ARMS.

By BT. LIEUT.-COL. G. LE Q. MARTEL, D.S.O., M.C., R.E.

As very few R.E. officers spend more than a short portion of their service with field companies, it naturally follows that most officers find themselves short of experience and ideas when they are sent to command a field unit after perhaps a long spell of other work. If it was possible to collect a list of tips and notes from the officers who have had more experience with field companies and issue these in pamphlet form and keep them up-to-date, it would be of great value to the units and probably to C.R.E.s as well. Failing this, some short articles in the *R.E. Journal* might help and the following notes are written with this in view. They are merely suggestions and only deal with a small part of *Field Company Training*, but they may give rise to discussions and lead to further contributions, which will be of more general assistance to everyone.

These notes deal with the training of field companies with battalions or infantry brigades. It so often happens that field companies march out with brigades and do practically nothing for days on end, that everyone loses interest. This is mainly due, of course, to the difficulty of construction or destruction under peace conditions; now that we are slowly getting some mobile bridging equipment, we can sometimes have a day of practical work in bridging, but there are many other ways in which we can take an active part, if sufficient forethought and imagination are used. Two examples of the type of work that can be arranged are as follows.

DEMOLITIONS.

A reconnaissance is made of the training area where battalions or brigades are training, and some natural obstacle selected over which a bridge can be constructed. The obstacle should, for choice, be a river or stream, but an irrigation cut, or anything of that nature, will suffice if necessary. A site on this obstacle is selected at some point within, say, five miles of the camp, and at this point the ground is dug away if necessary, so as to provide a short length of artificial obstacle, and the remainder of the obstacle must be marked out and considered as impassable to troops. A bridge is then built at this point. Most of the bridge will have to be timber work to avoid

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expense, but a small portion should be solidly constructed for demolition purposes, *e.g.*, one pair of trestles might be made of concrete, or a concrete retaining wall can be built as an abutment. The demolition of either of these would provide useful training.

The infantry now work out a scheme in which a rearguard has to withdraw across the obstacle, and when they have done so, the sappers demolish the bridge. The following are the points that are brought out :—

(*a*) The infantry will probably want some additional footbridges across the river, so as to avoid having to converge and cross at one bridge which may be under fire. Will the infantry commander think of this and will the R.E. officer remind him of it ? If possible, the sappers should actually erect these footbridges before the rearguard withdraws over the obstacle.

(*b*) What instructions are given to the R.E. officers ? Is he told what to do in case the enemy suddenly appear at the bridge, and who will instruct him to blow it up ?

(*c*) Is the local defence of the bridge organized so that the sappers are not rushed at the last moment and so fail to demolish the bridge? What will the R.E. officer or N.C.O. do if an A.C. suddenly appears at the bridge, when the whole of the rearguard is still on the far side ?

(*d*) If there is only time for a hasty demolition, the roadway or pier will probably have to be attacked. If there is more time, the abutment can be mined as well. If there is not time to do this during the scheme, it can be demolished later as a demonstration.

Road Blocks.

Most infantry officers put some sappers in the advance guard because the book says so, but they have little idea as to what they would do in war. A very common duty is the removal of road blocks, and the value of sappers for this work can easily be demonstrated. An obstacle which can be imaginary or real is again selected, and a road block placed at the only crossing place over the obstacle. If a bridge or causeway over a river is selected which cannot be blocked because of civilian traffic, it can sometimes be arranged to put the road block down on some ground clear of the bridge, and for the umpires to close the bridge until the block is removed. The block should be a really substantial one, such as a crib or, say, 18" tree trunks dogged together. If possible, the block should be constructed secretly during the previous night by one section of sappers, and the

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sappers who will have to remove it should not be allowed to see it. The infantry now make up an advance guard scheme and advance along the road and bump into the block, and the following points are brought out :—

(1) How soon do they get the message back that the road is blocked ?

(2) Is there an R.E. reconnaissance party well forward to send back a report as to what tools are required, and how long it will take to remove the block ?

(3) Were there some sappers well forward to deal with this ?

(4) Did the advance guard commander at once consult his sapper or did he panic and try to get round by some other way ?

It is very instructive to let the infantry have a try at removing the block with their own battalion tools, on the assumption that they had no sappers. If green timber is used and well dogged, they will not remove a single log in an hour. No infantry officer who has been " caught out " like this will ever forget again to ask for sappers with his advanced guard.

It will usually be found that battalion or brigade commanders are quite ready to work in schemes of this nature with their normal training, provided they are consulted well beforehand, and the units are very enthusiastic in carrying them out. There is no better way of instilling the correct method of co-operation between engineers and other arms and in bringing to light the importance of R.E. work, which is apt to be forgotten as we recede further from the War.

Finally, the point often arises in discussions with other arms as to what work the R.E. units should undertake. Whenever the warfare has stabilized for even a short period, there is so much R.E. work required that it is laid down for our protection that it is the duty of the troops themselves to do their own wiring and the simpler work in connection with their defences. In moving warfare, however, there is sometimes little work for the sappers to carry out. Yet under these circumstances, one often finds an R.E. officer refusing to do some work such as wiring, because the book lays down that it is not " his job." It is very unlikely that this was ever intended and there is no doubt that the sappers should do everything they can to help the cause, merely keeping in mind that we must train the infantry in peace, because there will be many occasions when we will be totally unable to help them with such work in war. With this proviso, we should be prepared to do wiring or any other work during the moving warfare in the early stages, if there is no technical work such as bridge-building or demolitions to be carried out.

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SHORTCOMINGS OF REINFORCED CONCRETE ROAD DESIGN.

By CAPTAIN A. MINNIS, R.E.

PLAIN and reinforced concrete as materials for road construction have made a rapid advance since the War. Thousands of miles of concrete—principally " reinforced "—have been laid over a sufficient length of time to provide data on which to base an estimate of their success.

The objects of this article are: to summarize briefly the history of this type of construction; to note the defects in modern R.C. roads; and then to present the writer's opinions as to the reasons for those defects.

Comment being practically confined to the shortcomings of R.C. roads and their designers, criticism is necessarily chiefly destructive.

To be complete, the article should go on to show how R.C. roads ought to be designed and built. But to do so would make it inordinately long. It is proposed, if permission be given, to follow up the arguments here put forward by another article in which the principles of good design will be set forth, with a few typical examples of their application in practice.

HISTORY.

This brief historical summary does not attempt to start at the beginnings of concrete roads; it is concerned only with roads built of Portland cement concrete, plain or reinforced.

Portland cement was first produced on a commercial scale by a Yorkshireman named Aspden, rather more than a hundred years ago, but it was not until the 'sixties that it definitely took the lead away from Roman cement.

In 1865, the first P.C.C. road was laid at Inverness; presumably not with conspicuous success, because the material does not appear to have been used again for road-making until twenty years later, when Gillespie Crescent, Edinburgh, was paved with mass concrete, 10 inches thick. From this time and on to the early 'nineties, a mild epidemic of P.C.C. road-making appears to have occurred over most of the " up-to-date " world, but principally amongst the large municipalities of Great Britain and the United States of America.

The reasons are not far to seek.

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Tar and bitumen had not then come into use as road binders to any appreciable extent.

Roads were principally made of water-bound macadam (for country roads and in town streets not subject to heavy traffic), or of granite or other hard stone setts (where traffic was heavy and the streets such as were required to last a long time without the inconvenience of renewal).

Traffic was practically all horse-drawn and steel-tyred. The not-too-hard stones which lent themselves best to water-binding wore fairly easily under traffic, so that macadam roads were sludgy in wet, and dusty in dry weather. They were cheap and gave a good foothold to horses, with reasonably quiet running under wheels.

Granite setts were too hard to wear into sludge and dust, but they had to be laid with joints sufficiently coarse to give a good foothold. They were, therefore, very noisy under steel tyres, and they were expensive in first cost.

Portland cement concrete seemed to promise most of the advantages of both types.

Since consolidation by roller and water was replaced by using cement mortar as binder, harder stones could be used than for water-bound macadam; so that the road promised long life and cleanliness, and the absence of joints promised more silent running than granite setts. The results were disappointing—concrete roads had faults in practice which had not been foreseen.

Cracks occurred, due to shrinkage on setting, temperature changes, and subsidence of the foundations, and these cracks made starting points for rapid deterioration; also the surface was disliked by horse-owners, being slippery for horses and harsh under steel tyres.

Concrete, as a running surface, fell into disrepute; though, as soling to be paved with granite setts (for hard use) and wood blocks (when silence was the primary consideration) its use increased.

As rubber-tyred motor traffic increased, the objections to noise and poor foothold began to lose weight, and it is probable that concrete roads would have made a very large advance in the five years before the War, had not circumstances caused another rival to appear. The necessity for finding a palliative for the dust nuisance on water-bound macadam roads brought tar and bitumen into use as top dressing. How the use of these materials as binders for macadam roads instead of water followed their use as top dressings, is familiar to everyone, but that is not for discussion here.

It is mentioned only because it was probably the principal reason why concrete did not receive the attention it deserved at that time from those interested in road development and maintenance.

There being an excellent and easily used makeshift which did not require much thought by the engineer, or skill on the part of the

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labourer, there was little incentive to try to overcome the difficulties in the use of a potentially superior material.

(A parallel might be drawn with the killing of the steam motor-car by the internal combustion engine, due largely to timely developments in the production of petrol.)

The use of reinforced concrete in structural engineering, however, developed rapidly, and its success encouraged engineers to try the new *composite material* for road-making.

Just before and during the War a few reinforced concrete roads were made, notably in Melbourne (1914), Tilbury (1917) and Long Island (1917); and immediately after the War, both plain and reinforced concrete roads received a huge boost in the United States, due largely to the enterprise and influence of the cement manufacturers in that country.

The material has now definitely established itself as a first-class road-making medium; but there is room for great improvements in its use before it becomes truly efficient, there being far too great a gap between the performance possible and that which is usually obtained.

A Few General Remarks on the Present State of Design.

Before proceeding further, the reader's indulgence is asked for the rather loose use of the word "foundations."

It is a matter of some importance to use the right word for the particular part meant when writing of roads which are built in successive layers, such as macadam roads, or roads paved with a surface material which is of a nature distinct from material below.

But reinforced concrete roads are peculiar, in that normally they consist of a layer of material which is itself soling, carpet and running surface all in one, sitting directly on the soil.

They may have a thin layer of sand or clinker between soil and concrete for drainage purposes, and on very unstable soil a bed of hardcore may be put down before placing the concrete, but such expedients are in no sense "soling": being used specifically for drainage or to improve the quality of the soil. They are, strictly speaking, precautionary measures used in particular circumstances, though their use is very frequent. The word "foundations," as used in this article, means whatever is immediately underneath the road slab, whether virgin soil, an old road, or a bridge deck.

Care will be taken to guard against ambiguity; and the reader is asked, if he is a stickler for terminology, to substitute whatever his pet expression may be, whether "formation," "sub-grade," or anytning else.

In what follows, reinforced concrete is the material discussed, plain concrete being unsuitable for road-making over any but soil

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or other bearing giving a very perfect foundation. There is practically no difference between the laying of the two types, but there is a great difference between the efficiency of a plain and a well designed reinforced road, especially over bad ground.

Unfortunately the majority of reinforced concrete roads are not well designed; if, indeed, they can be said to be ***designed*** at all.

There have been some roads laid to well-thought-out designs, and some will be illustrated in the article devoted to good road design; but such are the exception.

The stereotyped "design" (the inverted commas are not accidental), illustrated in Fig. 2 is by far the most common form of construction used, and it is the principal purpose of this article to show where, in the writer's opinion, it fails. There is good reason to believe that the continuance of most of the typical defects of R.C. roads is due to the uncritical acceptance of this "design," for no other reason, apparently, than that it is easier and less risky to follow a precedent than try to think out something better.

This statement may seem to be very sweeping; and objection to it may be raised by pointing to the manifest improvements of late years in reinforced concrete road construction.

But it does not follow, because some roads are better than others, that they cannot be improved, and in most cases where the stereotyped "design" has proved a success it is probable that the foundation soil is so good that plain concrete would have been equally successful. Some of the successes of this design are accidental; due to conditions of site, climate, shade, etc., but more to the excellence of modern cements.

Most of the improvements in R.C. road construction are due, not to the designer, but to the enormous strides made in the manufacture of cement; in the practice of concrete mixing and placing; and, to a much smaller degree, in the manufacture of reinforcing steel.

That is to say, that most of the credit belongs to the composite material, which has succeeded in producing good roads, although it has not always been used to its best advantage and has frequently been grossly misused.

Before discussing design in detail it will be useful to catalogue the principal defects of R.C. roads, then to discuss the causes of those defects, and finally to summarize such conclusions as are arrived at from this discussion.

Principal Defects.

(1) Difficulty of opening up for service pipes and cables.
(2) Difficulty of repairs.
(3) Length of time a road is out of use during construction.
(4) Weakness of joints—causing cracking and disintegration.
(5) Waviness.

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(1) Is a very serious difficulty in the case of roads in districts which are developing. In towns and country districts the trouble is not—or should not be—serious, because in the former the run of pipes and cables is known and provision for access can be given, and in the latter the question seldom arises.

In suburbs of large cities, where building is continually going on, new sewers, water and gas mains and electricity supply cables are sooner or later provided to serve the shops and houses which follow new road construction.

Whatever the type of road, such cutting up and filling in as is required for these service installations spoils the road surface, but R.C. roads present the most difficulty in opening up, and suffer most damage in the process.

Though some ingenious—not to say mad—ideas have been put forward to make easy access everywhere to the foundations, the only practical solution lies in forecasting what mains, etc., will be required, and so placing them (*e.g.*, in tunnels) that they can be got at without disturbing the road surface.

(2) R.C. roads are more difficult to repair than other types, because of the stubbornness of the material. When bad places require patching it entails much more labour to cut out the patching hole to square sides than in the case of, say, tar macadam. Also, patches must be given time to set, and so require to be guarded from traffic for 24 hours at least. On the other hand, repair patches, once set, are much more effective than similar patches in macadam roads.

(3) This difficulty need not be dwelt upon. It is disappearing with the advance of quick setting and rapid hardening cements.

(4) The principal fault and the real *raison d'être* of this article. Cracking, at joints or at weak places, arises from several causes, though the great majority of people concerned with R.C. road-making lay the whole blame at the door of expansion and contraction, due to temperature changes.

Whilst agreeing that temperature changes probably do cause their share of cracking in roads of indifferent design, they are not, in the writer's opinion, the principal agents of cracking, even of badly designed roads.

Initial cracks are often due to shrinkage on setting, which cracks are made worse by expansion and contraction, due to changes in: (*i*) moisture content, and (*ii*) temperature.

Uneven settlement of foundations is also a principal cause of cracking, linked up with which is the primary cause of nearly all the trouble—careless or unintelligent design.

Warning to the Not-Very-Interested Reader.

Before going further, it is necessary to discuss certain properties of concrete, in order that those who are keenly interested in the

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material may follow the writer's main argument, even if they disagree with his conclusions. Others are cheerfully recommended to skip the next page or two.

Shrinkage.

Concrete is subject to two distinct conditions of shrinkage. The first and more important, is that which takes place on setting, and which is due entirely to chemical changes within the material itself.

It is this "setting shrinkage" which causes initial cracking of (say) a slab, the extremities of which are not free to follow up the setting concrete as it contracts towards the centre of its mass. Most of these cracks form very early in the setting, when the concrete has very little tensile strength and cannot pull in its outlying parts against such resistance (usually friction due to a rugged bearing surface) as it may encounter. It does not follow that shrinkage cracks will invariably take place close to the extremities or near the centre. They will occur where the concrete, relatively to effort required to produce local movement, is weakest.

The second condition of shrinkage is that which takes place when concrete, already set, is subjected to some external drying agency.

Concrete is, and remains, porous, and therefore under normal atmospheric conditions never dries out completely.

If it is subjected to a drying agency, such as sun and wind, it will shrink, but this shrinkage is distinct from the initial "setting-shrinkage," in that it is reversible by the application of moisture.

Concrete behaves in exactly the same way as timber, which is shrunk by seasoning to a practically stable condition before it is fit for use as structural material. It will afterwards shrink or swell very slightly according to its use in very dry or wet situations, but no amount of moisture will cause it to swell to its pre-seasoning volume.

Thus, the shrinkage of timber in seasoning is, like that of concrete in setting, not reversible, whereas shrinkage due to subsequent drying, both of timber and concrete, is reversible by the addition of moisture; and both materials, when in use, are subject to fluctuations in volume, due to variation of the water content.

It is the first, or setting shrinkage, which causes initial cracking of concrete; but secondary shrinkage (or swelling), although its effects are neither immediate nor obvious, is also a factor which should be considered in design.

Expansion and Contraction due to Temperature Changes.

There are two schools of thought about the question of the necessity for provision for changes in length of R.C. roads due to temperature variations. One party says that expansion joints at frequent intervals must be provided or the road will crack by contraction, or "blow up" by expansion. The other party prefers to lay the road in one continuous strip, the only intentional "joints" being

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where one day's work ends and the next begins. If any movement due to temperature changes takes place, then the road " will crack itself and make its own expansion joints where it wants them."

Opinions vary between the wide extremes of making the same allowance as is made in railway construction, on the grounds that concrete and steel have practically the same coefficient of expansion ; and of making no allowance whatever " because there's plenty of room for the road to do all its expanding sideways."

Both of these astonishing propositions have been made in the writer's hearing.

As the coefficients of expansion of concrete and steel are respectively 0·000006 and 0·0000065, there is, on the face of it, some reason for considering R.C. roads to be similar to railway metals in this matter of variation in length due to temperature changes.

But the analogy stops, literally, " on the face of it." Owing to the extremely poor conductivity of concrete, heat from the sun does not penetrate far below the top skin. Exposure for a whole day to hot sun (which would heat a rail through and through as much as 100° above night temperature, with great effect on its length) would have no appreciable effect on the temperature of good concrete below an inch or so from the exposed surface.

At night time, most of the sun's heat taken up during the day is given off again to the air, only a very small amount soaking down further into the mass. Given a very long period of hot weather, a concrete road must absorb in this way sufficient heat to raise the average temperature of the mass a little above " normal," and similarly a long period of hard frost will reduce the average temperature to near freezing point, but the total range of temperature through which the heart of a road slab passes will probably not exceed 35°, *i.e.*, from, say, 30° to 65°. Therefore, on account of the difference in conductivity alone, the alarming possible variation of over 3 feet per mile based on a range of temperature of about 100° in the case of railway metals, can be at once reduced to about a foot. Even this amount is again reduced when one considers the shrinkage caused by drying under hot sun. It is probable that even the surface of an R.C. road expands very little due to hot sun, because the tendency to expand is largely counteracted by shrinkage due to drying out.

It may be pointed out against this that roads laid in continuous strips *do* form their own " expansion joints " themselves, and that where this has not taken place roads have been known to " blow up." The answer to this is that nine out of ten such cracks as appear have nothing to do with temperature changes ; and that if the tenth case occurs there are always contributory causes, as well as expansion. An extremely small longitudinal expansion is sufficient to

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cause a road to "blow up" into transverse folds of considerable height.

Again, these transverse folds, it will be noticed, invariably occur as "blow-*ups*," not "blow-*downs*," the reason for this being that any tendency to buckle downwards is checked by resistance of the foundation and the steel reinforcement on the underside of the slab. As the slab is not reinforced against tensile stress near its upper surface, that surface tears apart, and the resulting fracture allows of local lifting which eases off the compression due to expansion. See Fig. 1.

Plastic Yield.

Before going on to a conclusion on this matter of "blowing up," it is necessary to make a short digression dealing with "plastic yield," a property of concrete which is known to too few of the users of that material; although the phenomenon has been known for thousands of years to users of timber.

A beam of concrete or unseasoned timber deflects when a load is first applied, due to elastic deflection. If the load is allowed to

FIG. 1.

remain, deflection increases as time goes on. On the load being removed, the beam recovers to the extent that the initial (or elastic) deflection disappears, leaving as a "permanent set" the additional deformation which occurs after the initial deflection. This "permanent set" is the result of "plastic yield," due to the combined effect of load and time.

It is not proposed to go further into this matter than is necessary for the present purpose. It is mentioned only in order to point out that concrete can, due to this plasticity, yield sufficiently to take up within itself, and without damage, compressive stress due to expansion, which stress is only very gradually applied.

All that is necessary is to stop the concrete buckling by reinforcement designed to prevent such fracture as is shown in Fig. 1.

Further, such reinforcement is necessary to take up the tensile stress which is set up by contraction.

It is the writer's opinion that a road could be laid in one continuous slab without any danger of trouble from *temperature changes* if reinforced top and bottom; such reinforcement serving the double duty of taking up tensile stress on contraction and preventing buckling on expansion.

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(Reverting to the parallel case of railway metals, cited by the expansion "fans," it may be noticed in passing that, even in that matter, expansion allowance may be completely omitted provided that firm anchorage against buckling is given. Modern practice in the laying of tram rails in streets, where the top of the rail is flush with the pavement, uses welded joints between rails, making a continuous jointless rail.)

It does not follow that continuous construction of R.C. roads is recommended; cracks from "setting shrinkage" would still occur, and variation due to wetting and drying. The opinion is expressed only with the object of laying the "expansion-by-heat" bogy, which has received far more attention from R.C. road-makers than its unimportance warrants.

Continuous Strip versus Jointed Construction.

The writer has already stated that continuous strip construction is not recommended, in spite of it being, in his opinion, possible so to design such continuous work as to eliminate all danger from temperature changes; and the reason given is that setting shrinkage would cause cracking. Therefore, jointed construction, in the form of short slabs, is necessary. But such jointed construction immediately places us where we were before as regards the danger of "blowing up" on expansion, if the slabs are butted closely together.

It would be useless to leave this question in such an undecided state; some idea of the necessary space to be left between slabs, and the best method of leaving it, must be given.

In this matter the two factors to be provided for are "setting shrinkage" and "expansion" (obviously "contraction" does not matter).

These two factors are mutually opposed in their effect on the road when laid, and the first can be made to allow for the second.

The setting shrinkage of concrete varies in amount due to several causes, the chief one being the quality of the mix; usually the richer the mix the greater the shrinkage.

But for average good concrete, setting shrinkage is about 0·0005 inch per inch, which is the same as the expansion due to a temperature rise of 91°F.

It has already been shown that full allowance for such a range of temperature is unnecessary.

If, therefore, slabs are laid on the "alternate bay" system (which is the most convenient method for practical work), sufficient allowance will be made for expansion if, when laying "even numbers" between the "odd numbers" already set, the edges of the odd numbers are coated with some greasy substance, so as to prevent adhesion of the new concrete. The new concrete of the "even numbers" will then shrink away from the joints, and spaces amounting to ·00025 inch per inch will be left over the whole length of the road.

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This shrinkage will thus provide easement equivalent to spaces between 40′ slabs of about $\frac{1}{8}$″. (This, of course, does not mean that there will be gaps $\frac{1}{8}$″ wide between slabs. The actual gaps will usually be about $\frac{1}{16}$″ wide, the remainder of the shrinkage being divided between many minute cracks in the slabs themselves. These cracks must first be closed by expansion before a slab can begin to exert any pressure on its neighbours.)

It is obvious, then, that the normal provision of an expansion joint by inserting a solid bitumen strip or wooden packing of about $\frac{3}{8}$″ thickness—this joint being again widened by shrinkage—is absurd. All that is necessary is to ensure that slabs are not actually joined; leaving the concrete to form its own easement during setting.

If, after the first few " even numbers " have been laid and have set, an inspection shows only a fine gap between their ends and those of the older " odd numbers " (as may well be the case with some qualities of concrete and with various cements), some misgivings may be felt as to the sufficiency of easement.

In such a case it would be as well to use a bitumen strip of (say) $\frac{1}{8}$″ thickness every five or six joints. More provision than that should never be necessary.

Cracks due to Faulty Design.

If one takes the broad view, *all* cracks are due to faulty design, because even those for which such causes as shrinkage, temperature changes, and conditions of site, can be blamed are in the last resort the fault of the designer, who should make his design to meet these dangers.

But there is one extremely common fault in design which is itself the cause of most really serious cracking—that is, the misuse of reinforcing steel by unintelligent placing or from a mistaken attempt at economy.

Makers of reinforced concrete roads may be roughly divided into three classes, those who know their materials well and take thought and care in design ; those who don't know much but take meticulous care in execution of work ; and those who may or may not know, but don't take the trouble to think out the problems of design, nor to supervise the execution of the work, for themselves.

The first class holds the select few, one of the other two includes the great majority.

The first class has made and is making what are, in the writer's opinion, the best roads of any kind ever built.

The second is making roads of bad design which achieve some measure of success because of the attention paid to details of concrete mixing and laying, whereby the material is enabled to perform duties which it ought never to be called upon to do. This is a large class.

The third class, also a large one, accepts the " designs " of the

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second class (because those of the first are usually a little more expensive), and takes very little trouble in the execution of the work. These people make, considering the materials, very bad roads.

Let us now examine the stereotyped " design " referred to earlier. It is illustrated in Fig. 2 and is due to someone of the second class

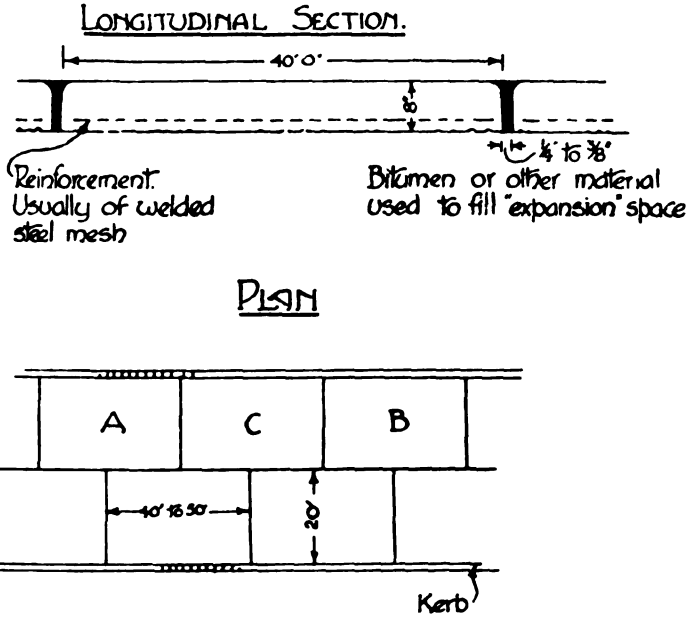

FIG. 2.

and used by the second and third classes to build most of the R.C. roads already finished and in construction.

The slabs are usually laid on the alternate bay system (A first, B second, and then C between A and B). The thickness, of course, varies, but will usually be about 8". It is sometimes made up of a bottom course of 5" to 6" thick of 4–2–1 concrete, using aggregate graded down from 2" to ⅛", and a " wearing " course of 3" to 2"

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thick of 3–1½–1 concrete, with aggregate graded down from ¾" to ⅛". The reinforcement used is usually a steel mesh placed 1½" to 2" above the formation. The joints are simple butt joints with a space between the slabs of about ¾", kept by placing boards on edge against the slabs already set, or by placing and leaving a strip of solid bitumen which forms the "filling" to the "expansion joints." When boards are used they are sometimes left to rot away, and are sometimes removed when the slab is set, the filling between slabs being bitumen run in hot.

This, very briefly, is the specification in most common use to-day, with variations which do not affect the essentials.

There are several minor points which are open to criticism, but for the present we are concerned with the placing of the reinforcement only. The slab is designed in the same way as a floor slab supported at its edges.

The reasoning on which it is based—the writer has heard it reiterated by a great diversity of people in sundry places—is, omitting irrelevancies and repetitions, as follows: "If you load a slab it deflects into a saucer shape. The constant repetition of this deflection compresses the soil under the centre of the slab until it eventually becomes permanently depressed, and the slab is then supported only on its sides. Consequently, the underside of the slab is always in tension in varying degrees of intensity; therefore, tensile reinforcement is necessary near the bottom; the top is in compression, which the concrete can deal with itself."

At the risk of insulting the reader, who will already have noticed that this reasoning exhibits its own weaknesses abundantly, its two principal fallacies will be pointed out.

The first is that the loading is assumed to be always more or less central. It is not. The normal run of traffic on a road puts every part of the surface at one time or another under maximum point loads. The second is the assumption that the slab is supported chiefly at its edges.

Whether such people as use this design agree or don't agree that their reasoning has been fairly presented, a glance at the placing of the reinforcement is sufficient to show that this assumption must have been made.

The reinforcement is placed near the underside of the slab, as it would be in the case of a floor slab carried on four walls without any intermediate supports.

This means, if it means anything, that the designer anticipates sagging bending only; because, if he thought that any useful support could be expected at any point between the edges, he would provide reinforcement against hogging bending, exactly as in the case of a floor slab continuous over several supports.

As he makes no such provision, only one deduction is possible

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(assuming that the designer has some knowledge of R.C. design): that is, that he is perfectly satisfied that "saucerwise" deflection only need be expected.

Now even if we assume the most favourable conditions—a perfectly elastic foundation of even consistency—the slab will seldom deflect "saucerwise"—never when two widely separated loads are on the slab at once.

The tendency to deflection will be, for representative conditions, as shown in Fig. 3, which shows a longitudinal section of a road slab under loads in various positions. A cross-section of the slab would show similar tendencies to deflection.

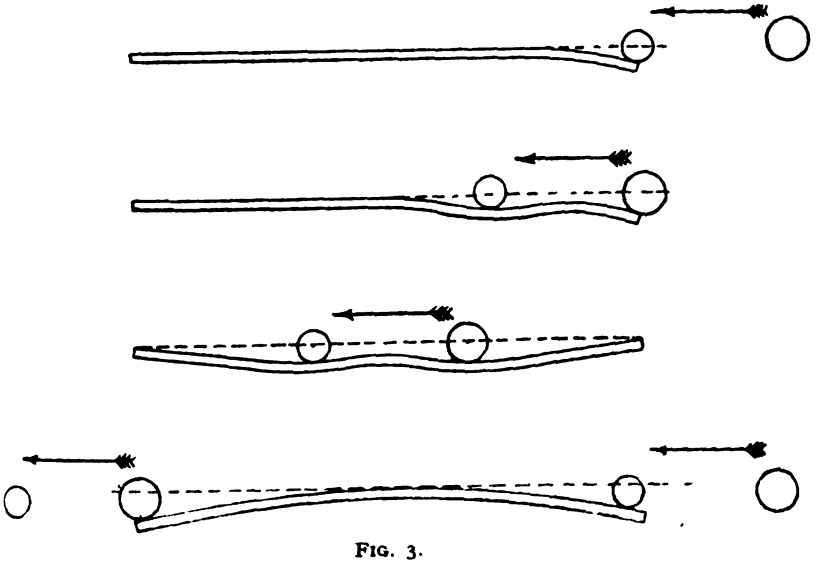

FIG. 3.

Under the ideal conditions assumed it is unlikely that any convexity sufficient to cause serious tension in the upper skin will occur in practice, but it is clear that the easy assumption that tension will occur only in the bottom skin will not do.

When we come to the more practical case of foundations which are not reliably consistent in bearing capacity, and are liable to local settlement due to water or filling of embankments, etc., the "saucerwise deflection" assumption explodes with a bang.

There are very few cases where the soil on which a road is built can be depended upon to settle evenly, and for this reason the condition of uneven settlement is called the "practical" one.

Whether a layer of clinker, or other drainage arrangements underlie the road slab, makes at best only a difference of degree in the effect of uneven settlement of the foundation.

If a singly reinforced slab is to remain sound, local settlement

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must take place, if at all, as shown in Fig. 4 (a), when the steel would be in its proper place.

Unfortunately, even the best-intentioned soil has little knowledge of the principles of R.C. design, and is just as likely to sink, as shown in Fig. 4 (b), when the steel would be useless. Even without appreciable settlement, the constant depression and lifting of the edge of the slab as it passes a wheel off itself to the next slab will cause consolidation of the soil locally to a level below the remainder; and the slab will soon lack support at its edges, thus being subjected to a hogging instead of a sagging bending action.

(It should be noticed that local consolidation of the soil, due to alterations of loading, will be much more likely at the edges of the slab than in the centre, because there is no connection between slabs, and, therefore, no support forward of the load point.)

The case of the slab in Fig. 4 (b) is not so bad if the settlement

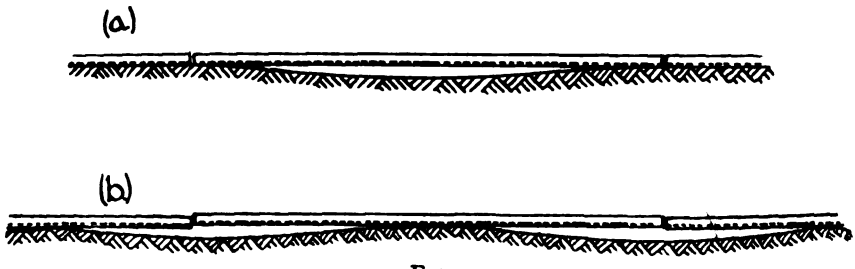

FIG. 4.

takes place in the middle of the transverse edge, as shown in Fig. 5 (a), but even here a crack, due to unforeseen tensile stress, will be very likely to start (as shown X–Y, Fig. 5 (a)).

Further trouble may be avoided by the *transverse* rods of the reinforcing mesh, which will be in their proper place as tensile reinforcement between A and B, the slab acting as a beam from A to B and bridging the depression. The *longitudinal* rods will, of course, be quite useless.

The case of the slabs in Fig. 5 (b) is much worse. Here the settlement has taken place at the corner of the slab, and, there being no chance for a beam such as A–B in Fig. 5 (a) to form itself, the corners become cantilevers projecting from the main slabs. They are, of course, not reinforced as cantilevers, and crack as indicated at XY and XY.

These results of uneven settlement are not a matter of conjecture only; they can be seen on any singly reinforced road; and some young officers may remember (when a certain singly reinforced road, which they saw in course of construction and later, was being laid) that they were told how these corners would crack within a couple of years or so. The prophecy was unnecessarily cautious; a great

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many cracks appeared within a month of opening, more are developing, and still more will continue to appear until the bed settles for good, if it ever does.

Sufficient has been said to show that this commonly used " design " fails on the point of most importance—that of the provision and placing of steel reinforcement. Single reinforcement is nearly useless,

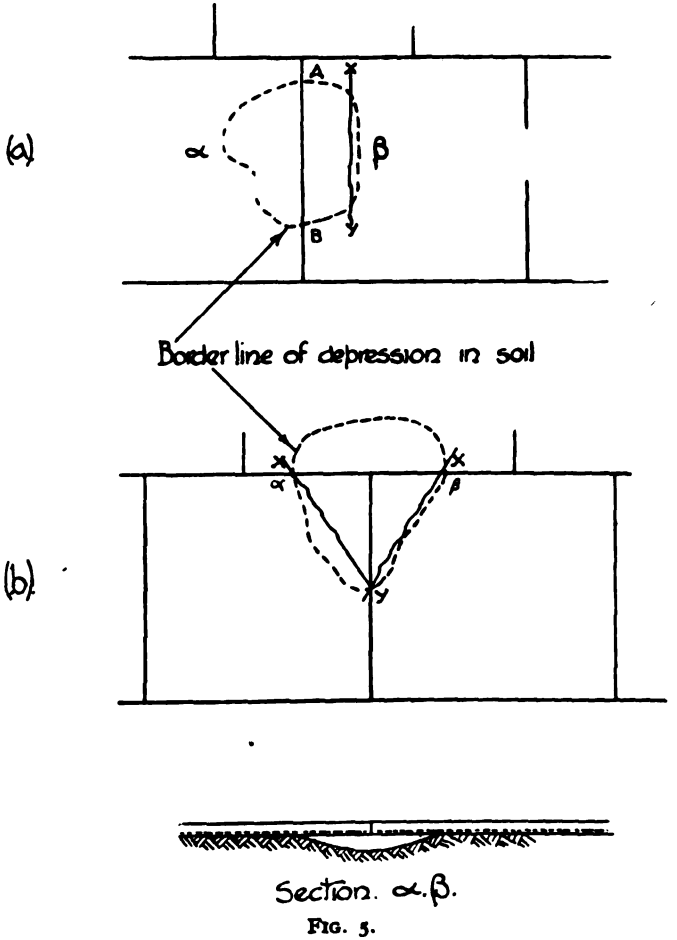

FIG. 5.

wherever placed; but if the extra cost of double reinforcement will not be faced, it is better to place the single layer of mesh near the top of the slab. The corners (which are the weakest places) will then be strengthened and the inevitable cracks where a depression is fully bridged will at any rate be underneath and out of sight.

Another point which has been brought out in the foregoing is that reinforcement across the slab is almost as important as longitudinal steel. (See Fig. 5 (a).) This is practically never provided in the

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"design" under discussion, the mesh commonly used having its "main" wires running longitudinally only, the transverse wires being merely spacers, placed at much wider centres than the main wires, and being usually of lighter gauge.

Even double reinforcement, which provides for both hogging and sagging deflections, does not always fill the bill completely. In addition, shear stress should be provided for in some cases.

We have not yet finished with the shortcomings of the "stereotyped design."

Leaving aside minor faults which will be dealt with by implication when a good design is discussed, there is one important failing which is worth special notice. It is bound up with what has already been said about the damage due to uneven settlement, and it refers to the transmission of loads from one slab to the next.

In this respect road slabs are in a similar position to railway metals; when a wheel arrives at the edge of a slab, the slab deflects

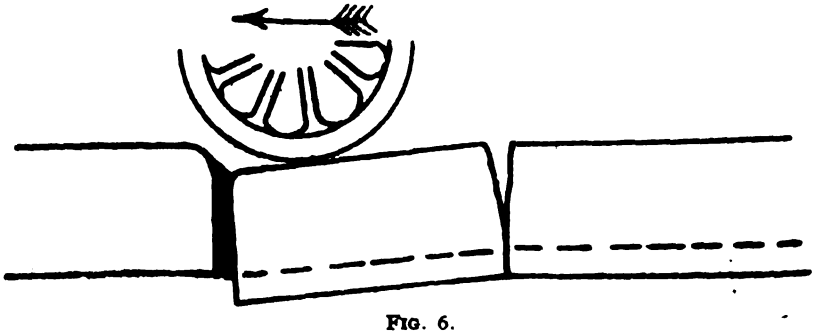

FIG. 6.

below the level of the next, and there is a slight jump when the load actually crosses the joint. Railway metals are fished in order to make one rail relieve the other as much as possible whilst the wheel is on the overhang, and to depress both rails together so as to minimize the jump. It is not possible to fish R.C. road slabs in this way—continuity of reinforcement has been tried, but is not a success; but it is possible to design a joint which will serve the same purpose.

The "design" under discussion makes no such attempt, with the consequence that joints suffer pounding, even if the slabs escape such cracking, as is shown in Fig. 6.

Waviness.

This is the last of the five defects. Waviness of R.C. roads has nothing in common with those corrugations of macadam roads with which every motorist is familiar. The crusts of macadam roads soften and expand at the same time, due to wet in the case of water-bound roads, and heat in the case of roads bound by tar or bitumen.

In their soft and expanded state, which causes folding into waves,

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these macadam crusts are subjected to pounding from traffic which exaggerates the waves and makes them permanent.

Concrete, having much greater compression strength, refuses to be kneaded about in this fashion, and, therefore, does not corrugate in the same way.

(It may here be remarked that the bastard type of road sometimes met with—a concrete road with a " waterproof carpet " of bitumen or tar—is for this present purpose, not a " concrete road " at all. It will corrugate, of course ; and for this reason is bad construction, the corrugations causing unpleasant running and needless impact on the concrete bottoming.)

But R.C. roads do develop waves, though the waves are much greater in length and much shallower than those of macadam roads. The effect felt by the motorist is nothing like so unpleasant as that from a corrugated macadam surface ; but there occur occasionally stretches of R.C. road on which waves are so regular in length as to develop a " period " in the springs of a car travelling at the right speed. The writer has never seen or heard of any explanation of this waviness, which is not of frequent occurrence, and is, therefore, not often discussed.

The two suggestions which follow are put forward with diffidence and the writer would welcome criticism or confirmation of them.

They are, that waviness may be caused by warping, or by deflection due to local sinking of foundations ; the former being variable according to atmospheric conditions and the latter being cumulative due to plastic yield.

Warping.

This follows from the same causes as warping of timber.

When one side of an R.C. road slab is exposed to the sun, it dries and shrinks, whilst the underside remains moist, retaining its original length and breadth. There is, therefore, a tendency to warp. The writer has seen cases of warping (of pre-cast concrete structural units).

Deflection.

This requires no explanation.

Assuming either or both of these suggestions to be true explanations of waviness, it will be of interest to notice some of the implications which ensue. In different cases :—

Either warping or deflection may be the sole cause of waving.

If deflection is the original cause, warping will probably exaggerate it.

If warping is the original cause, there will be a tendency for the edges of the slab to leave the foundation, and incidence of loading will tend to flatten it out.

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Waviness caused by warping would probably be less noticeable after a period of wet weather, and more noticeable after a spell of hot, dry weather.

In the case of a road laid in slabs of equal length, waving caused by warping would be regular over long stretches of road; whilst that caused by deflection would occur at irregular intervals depending upon variations in quality of the foundation.

CONCLUSIONS.

The writer's conclusions on the defects in most reinforced concrete road construction, with which the reader is invited to agree, are as follows :—

(1) That on most foundations it is impossible to forecast where the hard and soft places will be, and that it is, therefore, wrong to assume that any slab forming part of the road will necessarily have its principal support at its edges.

(2) That hogging bending is just as likely to occur as sagging bending; therefore, tensile stress may occur at either top or bottom of the slabs.

(3) It follows from (1) and (2) that single reinforcement, wherever placed, cannot provide for the varying incidence of stress. It can be in the place where it is wanted only by a fluke.

(4) That the surface cracks which form themselves at more or less regular intervals in singly reinforced roads laid in continuous strips, and which are popularly thought to be self-made "expansion joints," have usually nothing to do with temperature changes. They are due, sometimes to shrinkage cracks, and sometimes to hogging bending over relatively firm places following depression of the foundation between them.

(5) That a road slab requires transverse as well as longitudinal reinforcement.

(6) That temperature changes need not be considered if the road is laid in a manner which makes use of setting shrinkage.

(7) That corners of slabs require special thought in design, and that joints between adjacent slabs must be so designed as to make the slabs mutually supporting.

And, finally, that most of the faults to be found in R.C. roads have their origin in the designer's office.

Some few engineers have already shown that the composite material is the best road-making medium yet produced; and its superiority would be universally proved if a small fraction of the thought and care bestowed on relatively unimportant details of concrete mixing on the job were given to preliminary work on the drawing-board.

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THE GERMAN ENGINEER AND PIONEER CORPS.

(INGENIEUR=UND PIONIER=KORPS.)

By COLONEL G. H. ADDISON, C.M.G., D.S.O.

PART I.

INTRODUCTION.

"To enter the war at full strength from the start, Germany needed in peace 100 instead of 35 Pioneer battalions, and the war showed that this would have been feasible if all effectives had been called up. It would have been both cheaper and more businesslike to have carried the burden of this armament, than to lose the World War and be obliged to pay the consequences. If a prudent, calm German people, a far-seeing, wise Government, a vigorous, resolute, supreme power had ensured the necessary increase in time, if only by two-thirds, the outcome of the war would have been very different, and victory won in 1914; it may even be that war would not have come at all. Not by weak-kneed pacificism, but by the doughty man at-arms, by the strongest battalions is peace assured to a nation And so all the self-sacrifice, all the devotion of the 50,000 Pioneer dead could not avert the Fatherland's doom. Once again has Segestes betrayed the people of Hermann."

"This is the end of the story;
The Nibelungs' doom and despair."*

This, freely translated, is the end of Lieut.-Colonel Augustin's story of the development of the German Engineer and Pioneer Corps during the Great War.† It is an interesting and in some ways surprising story. Germany entered the war with a Pioneer organization that provided three field companies to every two divisions, with no Army or General Headquarter reserves, other than a few fortress Pioneer regiments which events might or might not make available for the field army. At the height of the struggle, there were still divisions with only a single field company, and with over 200 divisions in the field only 9 Pioneer battalions (36 companies) remained unallotted to divisions. The story of the war, so far as the Engineer and Pioneer Corps was concerned, is one of a long hopeless struggle to make up for a bad start. Remembering the completeness of German pre-war organization, it seems incredible that the allotment of Pioneers to the field army in 1914 should have been proportionately so little greater, as regards officers even less, than what had proved necessary a century earlier. The long con-

* In A.D. 9, Arminius (the Latin form of Hermann) led the people of South Germany in revolt against the Romans. In spite of the treachery of Segestes, who betrayed the plans to the Roman commander, the revolt was completely successful, and Hermann became the German national hero.

† "Die Entwicklung der Pionier—Waffe im deutschen Heere während des Weltkrieges," Von Oberstleutnant Augustin. Mittler & Sohn: Berlin.

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tinued neglect, it might almost be called contempt, of the technical arm offers an interesting study of Prussian military psychology. The following pages are, however, designed as a plain story and not as a critical study. The original intention was to confine the story to the period of the Great War, but it soon became apparent that some knowledge of what had gone before was necessary to an appreciation of how and why things happened during the war. The result is a general history based on a number of German works which are tabulated at the end of Part II ; in addition, reference has been made to various official handbooks and publications in order to check and fill in gaps in the other works. It should be remembered that the original authors are all officers of the Engineer arm, and it is only natural that their views should be coloured by the peculiar conditions attaching to it. This is of some importance when expressions of opinion rather than statements of fact are in question. On all points in connection with the German Army, whether dealing with experiences of the past or lessons for the future, the opinions recorded are those of the original authors and not of the present writer, whose comments are generally confined to footnotes. The translation of the German word "*Pionier*" always presents difficulties. It has quite a different significance from "Pioneer" as understood in the British Army; but, for various reasons, the more usual translation "Engineer" would not be convenient. The plan adopted is to render literally "Engineer" for "*Ingenieur*," and "Pioneer" for "*Pionier*." Readers who are not already acquainted with the organization of the German Corps may find it helpful to glance at page 248 before reading further. Attention was first drawn to Lieut.-Colonel Augustin's work by Sir James Edmonds, to whom acknowledgments are also due for much valuable advice and help in the preparation of this paper.

EARLY HISTORY.

Pre-Napoleonic Period.

We usually begin the history of our own Corps with Waldivus Ingeniator, 1066, or at all events not later than Edward III.'s body of engineers, gunners and other artificers at Calais in 1346. There is no record of military engineers in Prussia until the second half of the 17th century when, under Frederick William of Brandenburg ("The Great Elector"), small parties of "pontoniers" and "miners" were attached to the artillery. The pontoniers were formed in squads of 10 to 15 men under a "bridge-master"; they had no bridging equipment, and it is evident that the artillery had to do most of the work. The greatest bridging exploit of this period occurred in 1689, when Frederick crossed the Rhine with 20,000 Brandenburgers over an improvised bridge. Frederick William I. ("The Soldiers' King") formed the first independent company of pontoniers, but its strength was only 2 non-commissioned officers, 1 master and 20 men. He also introduced an equipment consisting

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of copper pontoons, each carried on a light wagon, with anchors, breastlines, boathooks, etc., but no superstructure. This company took part both in the Swedish War of 1718 and the French War of 1735. Like the pontoniers, the miners were at first attached to the artillery, only occasionally being placed under command of a miner officer. Both engineers and miners were employed at the Siege of Stettin in 1677, and this is the first record in Prussian annals of the use of "engineers" in a siege. In 1690, a regular miner company was formed, but of low strength, and with no regular status in the army.

At the end of the second Silesian campaign, Frederick the Great formed both pontoniers and miners into separate corps; they had no fixed establishment, but were recruited as and when required for service. The copper pontoons were, at the same time, replaced by wooden boats, of a type that lasted until 1860, when the first iron pontoon was introduced. Frederick also organized a Pioneer battalion, but the losses of the Seven Years' War led to its conversion into Fusiliers.

At the beginning of the Napoleonic Wars, the Prussian Army, of roughly eight to nine Corps, had only two and a half weak pontoon companies; Austria had one battalion of four companies. Russia was better provided, and in 1812 had 6 pioneer battalions, and 20 pontoon companies with ample equipment, attached to the Artillery. In France, until the Revolution, only artillery personnel seems to have been employed in bridging, but separate units were quickly formed which, by 1801, far outnumbered all the other armies combined, with the exception of the Russian. In 1809, Napoleon demanded two pontoon companies from Bavaria. These were the first technical troops to be formed in that country, and the Bavarian Pioneer Corps is their direct descendant.

Birth of the Prussian Engineer and Pioneer Corps.

In the general break-up of Prussia, both Pontonier and Miner Corps disappeared. When the army was reorganized in 1809–10, pontoniers, miners and engineers were amalgamated by Royal Decree into a single composite Corps. Various dates are given for the actual birthday of the Engineer and Pioneer Corps, which was at first composed of a Corps of Engineers (officers) and three companies of Pioneers, all that was allowed by the Peace of Tilsit. As first constituted, each company comprised in peace miners, sappers and pontoniers in the proportion 1 : 2 : 1. For war, the miners were to be formed into four fortress companies; the remainder into field companies (2 officers, 81 other ranks), consisting of two sapper and one pontonier sections. The distinction between fortress and field companies soon disappeared in the French War, siege operations during 1815 being almost entirely conducted by field companies, not unlike the experiences of a hundred years later. By 1815, the number of companies had risen to 21, roughly one per division, and the strength of each company to 200. An Engineer officer was

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attached to each brigade headquarters, and with every Corps there was an Engineer and Pioneer Commander, with at least two other officers. These details are chiefly of interest for purposes of comparison with 1914.

The regulations of 1809 were signed by Scharnhorst, Gneisenau, Pullet, Boyen and Leithold. To Scharnhorst, as head of the reform commission, fell the executive duty of putting the reorganization into operation. He may be regarded as the first chief of the Engineer and Pioneer Corps, and so long as he remained in control the Corps was in close touch with the staff and the rest of the army. The final downfall of Napoleon left Prussia with restored confidence and strong forces. The army had so changed in size and character that drastic reorganization of peace establishments had to be undertaken; in particular, the need for much greater independence in the constitution of the principal arms was recognized. But the effect on the Engineer and Pioneer Corps was disastrous, for it was relegated to a subordinate position which soon developed into a state of complete isolation from the fighting arms. This condition of affairs, introduced in defiance of every lesson of the war, was to have a lasting effect not only on the Corps but on the whole technical service of the German Army.

The period that followed was marked by notable developments of science and progress of civilization in Europe. Population increased rapidly, finance flourished, hundreds of miles of road were built, new industries sprang up, and Germany began to look for her place in the sun. Machine shops, first established in Aix by the Englishman, James Cockerill, were copied in Germany by Von Hummel, Freund and Egells; and in 1826 the younger Krupp took over his father's primitive steel works at Essen, which in the course of a few decades were to outstrip all foreign competitors. But time was still to elapse before their importance to war technique was recognized. The Pioneers, one of whose duties at this time was to take over garrison guards when all other troops were on manœuvres, had little opportunity to interest themselves in scientific development. Their interest was first awakened in connection with railways and telegraphs. The army was slow to take either of them seriously, the general view being expressed in a paper written by the Chief of Staff, to the effect that it was impossible to contemplate the use of such new-fangled contrivances in war, where risk of failure so far outweighed possibility of success. This was in 1836, and some years later the Chief of Engineers, General Aster, becoming alarmed at the growth of railways and their possible influence on the defence of fortresses, put forward a demand that no lines should be permitted to pass through a fortress, and that where they even approached its neighbourhood strict military control should be established and complete preparations for demolition made. The War Minister, Boyen, with more vision, laid emphasis on the strategical advantages to be

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gained by the defenders. When it is remembered that the term fortress covered many great towns, such as Cologne, it is not surprising that, in spite of military doubts, railway construction continued to follow the dictates of trade and of topography. Aster apparently took no steps to train technical troops either in construction or destruction.

The history of telegraphs is very similar, arguments of the same kind being advanced as to their possible danger to the army, and the necessity of control by the War Ministry. This led, in 1849, to the appointment of an Artillery Colonel as Director of State Telegraph Services under the Board of Trade, much to the chagrin of this department. The struggle to militarize state telegraphs continued throughout the next fifty years; but in the technical development of the service the Pioneers had no share.

The Corps of Officers.

In the earlier days of its existence, the officer corps went through many trials and tribulations. Starting with 37 trained Engineers in 1810, it had been built up by 1815 to a strength of 175, most of whom had no engineering training or experience except such as they gained in the war. The pre-war regulars went rapidly to the top, where they remained, causing complete stagnation in promotion; for example, the Chief of Engineers became Major-General at the age of 43, while there were under him subalterns of 37 and Captains of 50. To add to the difficulties caused by post-war reductions, fortress construction and maintenance were formally entrusted to the Engineers in 1822. In the course of reorganization, there had been a great opportunity to broaden the scope of military and technical training of officers, but it was not taken; and in 1816, the study of tactics was cut out of the syllabus of the joint artillery and engineer school, as being unnecessary for technical officers. The chief aim of authority at this time was to get cheap fortress construction out of the corps, which became more and more divorced from the rest of the army. This applied equally to the Pioneer companies, and attempts to secure for them a share in field training and manœuvres met with stern condemnation as being a misuse of technical troops.

General Army Reorganization of 1860–61.

In 1839, each army corps was provided with an organized column of entrenching-tool vehicles, and some years later a pontoon train was formed for every corps. No other developments occurred until 1860, when a general reorganization of the army began. In the course of this, Pioneer companies were grouped in battalions, each composed of one company of pontoniers, two of sappers, and one of miners, thus shifting the principle of unity from the company to the battalion. The total strength of a battalion was 18 officers and 482 other ranks, which was also decreed to be the war establishment. The battalion organization was based on purely peace considerations

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of command and administration; it was not adaptable to ordinary war formations, and led ultimately to many of the difficulties encountered during the Great War. However, the general scheme, which was carried out under Count Radziwill, a distinguished infantry general, as Chief of Engineers, seems to have been approved by the majority of Engineer officers at the time. The year's training of the battalion, as then laid down, was to consist of: recruit drills, 3 months; company training, 3 months; battalion exercises, 1 month; section leading and field exercises, 10 weeks; revetments, 3 weeks; trench-digging, 1 week; pontooning, 3 weeks; siege operations, 3 weeks; afternoons throughout the year; in summer, swimming, gymnastics and general Pioneer duties; in winter, classes and schools.

A scheme was also started in 1861, of sending Engineer officers to foreign countries to study developments in fortification; the first to be dispatched went to Antwerp, Lille, Cracow and Lemberg; and two to England to study coast defences, especially the latest designs of steel-armoured casemates.

The Wars of 1864 *and* 1866.

The inherent weakness of the Pioneer organization became apparent in the campaigns of 1864 and 1866, during which all the heroism and devotion of the troops themselves could not make up for inadequate numbers and lack of co-operation. The need for properly organized technical services was also emphasized, particularly in the Austrian War, for which both railway and telegraph troops had to be improvised. Four telegraph detachments were formed of state telegraphs personnel with a small nucleus of peace-trained Pioneers; three field railway detachments of civil railwaymen with a small Pioneer section attached to each; the whole under the orders of an Engineer officer attached to the Army Staff. After the war, a committee, set up by von Moltke, severely criticized the ignorance displayed by higher commanders in their handling of the Pioneers, and also stressed the need for Engineer officers to have wider knowledge of the principles and conduct of field operations. It recommended that there should always be a senior Engineer officer with the staff of every higher formation to advise the commander and convey his orders to the Pioneer troops.

The Franco-German War.

When the Franco-German War broke out in 1870, the general position had altered very little, although one important administrative change had been introduced. The Austrian War had shown the fallacy of separating pontoniers, sappers and miners, and shortly afterwards the battalion was reorganized in five companies: 3 field, 1 reserve and 1 fortress, all composed solely of "Pioneers." On mobilization, battalions were broken up; the commander joined the Army Corps Staff, single field companies were allotted to various formations, and the fortress companies to fortress garrisons. In all,

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49 field and 39 fortress companies were mobilized. At an early stage, nine of the latter were diverted to the field army to reinforce the field companies, and during the advance nine more joined L. of C. for railway and general maintenance work; of the remainder, all but six were engaged in the Siege of Strassburg. Each peace fortress company had to mobilize three units, which were made up of 6% active, 6% reserve and 88% Landwehr personnel; 70% of them being fathers of families. Telegraph and railway detachments were specially formed, as in 1866. Other technical units comprised a field photographic section; a mobile torpedo (submarine mining) detachment, designed to block the Seine at Havre; and two balloon detachments for which the personnel had been hastily trained with balloons obtained from England. The Corps of Engineer Officers was much below establishment all through the war, and was never made up, in spite of various shifts. Numerous examples are quoted of delays in operations and unnecessarily heavy losses on the part of the infantry, owing to lack of technical help. However, on the whole, a rather brighter picture is painted than of the earlier wars; the gallantry of the Pioneer troops was recognized by the other arms with whom they often fought shoulder to shoulder; and legitimate hopes were raised that the future would bring wider recognition and increased opportunities to the technical arm.

Period 1871–1914.

These hopes were not realized. The very completeness of the victory led the German higher command to ignore shortcomings that had seemed so obvious to the Pioneers themselves, and such changes as were made had even a narrowing effect on the role of the Corps. Minor improvements were made in the constitution of a battalion; but railways were completely separated in 1875; and so, to all intents and purposes, were telegraphs, although the Chief of the Engineer and Pioneer Corps continued to exercise powers of inspection until 1899. For administrative purposes a regular chain of Fortress and Pioneer Inspectorates was created under a cabinet order of 1885; each inspectorate was headed by a Major-General, immediately responsible to the "Chief of the Engineer and Pioneer Corps and Inspector-General of Fortifications," who reported direct to the Emperor. All the officers of the inspectorates were Engineers, and the state of isolation of the Corps was thus perpetuated. It was the considered opinion of higher authority that Army Corps or other high commanders should not be saddled with responsibility for inspection or training of troops, with the technical details of whose work they could not be familiar.

The first real signs of improvement followed the appointment, in 1898, of another infantryman to be Chief of the Corps. This was Lieut.-General Baron Colmar von der Goltz, well known to all military students as the author of *The Conduct of War*, *The Nation in Arms* and other standard works. The appointment was made for

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the definite purpose of bringing the Pioneers into the army and, under his direction, single Pioneer companies were, at long last, permitted to take part in divisional and corps manœuvres; he also organized special Pioneer exercises on a large scale, which not only afforded valuable experience to the Pioneers, but served to arouse the interest of commanders and staffs. The Emperor became personally interested and drew up a comprehensive scheme for what he considered to be the correct distribution and training of divisional Pioneers; although it met with scant support at the time,* the organization that he proposed was very similar to what was actually approved, although not carried out, in 1918.

The lessons of the Russo–Japanese War led to some improvement in the Pioneer reserve position; and to increased interest in fortress warfare; pioneer battalions in fortress areas were given special training in siege operations, and a scheme was worked out for the formation of Fortress Pioneer regiments in war. Finally, Army Corps commanders were given powers of inspection over the Pioneer troops in their district, though there is little evidence that they were exercised.

Von der Goltz's work was carried on by his successors, von Beseler and von Mudra;† the latter was responsible for the slogan, "*Pionier sein, heisst angreifen*" ("To be a Pioneer means to attack").

On the whole, although the period between 1870 and 1914 produced some improvement in minor details, the position of the Engineer and Pioneer Corps in relation to the rest of the army remained generally much as it had always been, and the chief claim to recognition rested on their ability to take part in the infantry battle. Training in field works and bridging had reached a very high standard, and Lieut.-Colonel Augustin claims that, in spite of all difficulties, "better Pioneers the world never saw."

THE GREAT WAR PERIOD.

General Summary of the Position in 1914.

It will now be convenient to summarize in detail the position of affairs just before the outbreak of the World War.

The Engineer and Pioneer Corps comprised:—

(*i*) A Corps of Engineers; officers only.

(*ii*) A Corps of Fortress constructors, composed of:

- (*a*) Fortress Corps officers.
- (*b*) Fortress Corps officials (wardens).
- (*c*) Foremen of Works.

Both (*b*) and (*c*) being recruited from non-commissioned officers of Pioneers.

(*iii*) A Corps of Pioneers.

* In the orgy of ship-building that was going on at the time, there can have been little money available for army increases.

† Both Engineer officers and Staff College graduates. v. Beseler later commanded at the investment and capture of Antwerp; v. Mudra eventually commanded an Army in 1918, the only Engineer who did so.

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All officers started their career in a Pioneer battalion; and, after a minimum of 21 months' service, were sent to the technical school, where they specialized. All remained on one list for promotion and, in theory, were interchangeable; but, in practice, having once specialized they were only changed over in exceptional circumstances. The whole of the men were trained in the Pioneer battalions and only non-commissioned officers were eligible for transfer to the fortress branch. The normal period of service was two years, of which the first was devoted almost entirely to infantry training. No trade standards were laid down but, as far as possible, suitable men were selected from civil life.

The German Empire was divided into 25 Army Corps districts.* Two Pioneer battalions were allotted to each of 10 Corps, one battalion to each of the others, making a total of 35 battalions. With the exception of the III Corps, of which the headquarters was at Berlin, each of those with two Pioneer battalions included an important fortress, where the Pioneers were invariably quartered. The battalion consisted of 4 companies, each organized in 3 sections; in addition, 26 battalions had a searchlight section attached. Peace establishment of the battalion, 24 officers (including attached) and 644 other ranks; of a company, 5 officers and 152 other ranks. Total peace establishment of the Corps, in round numbers, 900 officers and 20,000 other ranks.

As regards other technical services with which the Engineer and Pioneer Corps was not concerned; railway, telegraph, balloon and aviation troops were directly under the Inspector-General of the Military Communication Service; barracks and military buildings, not coming under the head of fortifications, were in charge of the Barrack Construction department, a branch of the Intendance; Survey was a function of the General Staff.

For war, a battalion was expected to form three to five field companies, one or two being permanently attached to each division and one kept at disposal of the Corps commander; one Corps and two divisional bridging trains. Certain battalions had to mobilize detachments, each of 1 officer and 33 other ranks, to accompany cavalry divisions; also field and fortress searchlight sections. Others were to be formed into fortress regiments of two or three battalions, each with a siege train. The battalion staff (2 officers) joined the Army Corps headquarters.

The war establishment of a company was 6 officers (includes 1 medical officer and 1 paymaster) and 262 other ranks, organized as

* The organization of the infantry was:—
1 Corps = 2 Divisions.
1 Division = 2 Brigades, but 6 Divisions had 3 Brigades each.
1 Brigade = 2 Regiments, but 5 Brigades had 3 Regiments each.
1 Regiment = 3 Battalions.
1 Battalion = 4 Companies.
There were also 18 independent Jaeger Battalions.
Total battalions = 669.

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for peace in a headquarters and 3 sections. The transport consisted of three 2-horsed and one 4-horsed store wagons, 1 baggage wagon, 1 supply wagon, and 1 field kitchen ; the last three being all 2-horsed and forming the 2nd line transport. There was also 1 pack-horse.

Both in peace and war, all transport of Pioneer units was provided with horses and drivers from the Train ; so the personnel belonged to another branch of the service.

General Mobilization, August, 1914.

When army mobilization actually took place all units were brought up to war establishment, and additional units were raised from surplus men at the depots. These units combined to form Reserve Corps, Landwehr and Ersatz brigades. The majority of the reserve corps went straight into the field ; fresh corps were rapidly formed, and early in 1915 the reorganization of four-regiment divisions on a three-regiment basis was begun, by which means extra divisions were gradually added. A total of 93 divisions were actually put into the field in August, 1914, which had increased by March, 1915, to 135 ; at the end of 1916 there were 200, and the highest point, just over 230, was reached in June, 1917, and maintained for just a year. These details are needed in order to follow the course of the Pioneer development.

Pioneer Mobilization.

Immediately mobilization was ordered, each of the Pioneer battalions was duplicated ; the first battalion consisting of Nos. 1 to 3 regular companies, and the second of No. 4 regular and 2 reserve companies. Nine battalions labelled in peace as " fortress " formed themselves into Pioneer regiments, complete with regimental staff, and were earmarked for employment as army troops ; and nine reserve battalions were detailed to fortress garrisons. In the case of all other battalions, mobilization again spelt disintegration. The commander and headquarters went off to various corps and other staffs, while the companies were allotted, either singly or in pairs, to divisions. Landwehr and Landsturm companies were raised to accompany corresponding formations ; also a number of Ersatz companies on a low establishment. Altogether from the 140 peace companies with a strength of some 20,000, were produced 379 companies of all sorts with a total strength of 80,000. Other units that were immediately formed comprised some 100 fortress and 25 field searchlight sections ; a heavy bridge train for the Rhine ; 25 Corps and 70 divisional bridging trains, with nearly 6,000 m. length of equipment ; 9 siege trains ; and 9 cavalry sections. So it will be seen that half the divisions that took the field only had a single field company, and about the same number had a searchlight section. Several of the reserve divisions and nearly all the reserve corps were short of a bridging train. There were no Pioneer corps troops.

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Pioneer regiments on a scale of roughly one per army were available as army troops. The Chief of the Engineer and Pioneer Corps with his Staff joined General Headquarters; and the various inspectors were attached to Army Group and Army Headquarters, all being replaced at home by officers of the reserve. It must be said that their position was in no way improved by mobilization; they still remained outside the normal staff organization and the chief continued to report direct to the Emperor. When mobilization was complete the total Pioneer strength amounted to roughly 120,000.

Results of breaking up Pioneer Battalions on Mobilization.

The process of mobilization proceeded smoothly and punctually in accordance with plans that had been worked out in great detail and revised every year. But the complete break-up of the peace organization could not fail to have serious results. No Pioneer officer or staff was allotted to divisional headquarters and the field company commander, or the senior where there were two companies, had to try to perform the dual role of staff officer and company commander. For the most part, divisional commanders ignored them altogether, with the inevitable result that ill-timed, inadequate, or in some cases no, orders were received by the field companies. Three early examples are quoted, of which the third has a particular interest :—

(*i*) During the advance of the 34th Infantry Brigade group against Liége, 5th to 8th August, a delay of 24 hours occurred at the Meuse before bridging started, although three field companies and two bridge trains were at the disposal of the brigade commander. Failure to keep the Pioneers informed and delay in sending them orders involved the brigade in an unsuccessful attack and heavy casualties, the delay in bridging having removed the element of surprise and left no time for proper reconnaissance.

(*ii*) The advance of the XVI Corps was delayed for a whole day on the Meuse below Verdun, in August, '14, owing to the failure of the divisional generals to give timely orders to their field companies, although the Pioneer commander at Corps Headquarters had made all arrangements for the necessary equipment to be at hand.

(*iii*) On the 8th September, 1914, von Klück ordered the IX Corps to detach a force to hold the line of the Marne against the advance of the British, and to destroy the Marne bridges. Von Quast, Commander of the IX Corps, detailed for this task a mixed brigade under Major-General Kraewel, to which one field company was allotted. The brigade reached Montreuil-Aux-Lions, 5 km. from the river, during the night, but the Pioneers never arrived, and apparently no

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orders reached the company.* The brigade was tired out, but there would still have been time during the morning of September 9th to destroy the bridges about La Ferté, which fell into the hands of the British later in the day. There was no senior Pioneer officer with any of the formations concerned, and even if the one field company had turned up, it would have been quite inadequate to deal with the 10 road and 7 railway bridges in the area.

Liaison between the Pioneers and the cavalry seems to have been better, though the Pioneer detachment with a cavalry division was deplorably small. In example (*i*) some cavalry on the right of the 34th Brigade crossed the Meuse on both improvised and equipment bridges without delay. In example (*iii*) the 2nd Cavalry division on Kraewel's right destroyed the two road bridges at La Ferté, though they left the railway bridge east of the town standing.†

Effects of Low Peace Establishments.

Further difficulties were introduced by the low peace establishment, which led to over-dilution with reservists and elderly men, with serious effects upon efficiency. Many of the men were physically unfit for the hardships of war service; they were also insufficiently trained in the more recent developments of Pioneer technique.

Shortage of bridging trains produced more complications, and delays in crossing the numerous French canals and rivers were frequent. The IX Corps is quoted as having lost 12 hours before crossing the Oise and Oise Canal at the end of August, owing to insufficient equipment; the corps bridging train having apparently had to be shared with the IX Reserve Corps.

Much the same state of affairs existed in connection with fortress mobilization. Plans had been worked out in great detail beforehand; but lack of touch between the higher command and the Engineers and Pioneers, and also failure to provide adequate reserves of tools and materials, led to much confusion and delay. In the event, no German fortress came within the sphere of active operations; had events turned out differently, extraordinary crises and breakdowns might have occurred.

* The German official monograph on the Marne says, "for reasons not now for certain discoverable the orders never reached it." See p. 287 of the *Army Quarterly*, January, 1930.

† Cavalry bridging equipment and vehicles actually belonged to cavalry regiments and not to the Pioneers; cavalry regiments also carried a quantity of explosives in their own transport.

(*To be continued.*)

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THE ABOR MILITARY AND POLITICAL MISSION, 1912–13.

Compiled from the Diary of the late Capt. P. G. Huddleston, R.E.

FOREWORD.

THE Abors are one of the savage tribes which inhabit the mountainous country in the extreme N.E. corner of the province of Assam.

In March, 1911, some Minyong Abors treacherously murdered their Political Officer, Mr. Williamson. The Government of India accordingly dispatched a military expedition up the Dihang Valley, in the cold weather of 1911–12, with the objects of punishing the Abors and of surveying as much of the country as possible, with a view to establishing a recognized frontier between Assam and Tibet.

As this military expedition failed to penetrate sufficiently far into the country to survey anything but a trifling part of it, the Government of India sent a Civil Mission back into the country the following year to concentrate on the work of exploration.

One of the few major outstanding geographical problems on our Indian frontiers at that time was that of the Tsang-Po—did this river break through the main Himalayan Range, and become the Dihang and so the Brahmaputra on the plains of Assam? If so, were there big falls in the gorge by which it cut through the Himalayas as stated by the explorer Kinthup, or a series of rapids?

During this season, 1912–13, there were two survey parties in the field. One party was under Captain O. H. B. Trenchard, R.E., and worked in the Dihang Valley; the second was under Captain C. P. Gunter, R.E., and explored the Valley of the Dibang.

The party under Captain Trenchard was divided into two. As stated in an article published in the *R.E. Journal* for May, 1915, reproduced from the *Records of the Survey of India*, Vol. IV, 1914, the programme laid down for the season was as follows:—

(1) *The Dihang Party.*—To explore and fix the Doshung La, and discover as much as possible of the geography north of the main ranges of the Himalayas; ascertain the point where the Tsang-po breaks through the main range; fix this range west of the Dihang in conjunction with the Siyom-Sigong party; fix the main range as far as possible east of the Dihang; discover whether the course of the Nagong Chu

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is north or south of the main range and whether it flows into the Tsang-po, the Dihang or the Dibang.

(2) *The Siyom–Sigong Party.*—To fix the main range of the Himalayas in conjunction with the Dihang party; fix the courses of the Siyom and Sigong Rivers and explore the passes said to be at the heads of these valleys; endeavour to discover the course of the Nia Chu, whether it becomes the Subansiri, the Siyom, or the Sigong, whether it flows north of the main range into the Tsang-po, or whether it breaks through the main range.

The writer of this diary, the late Captain P. G. Huddleston, R.E., was in charge of the Siyom–Sigong Party. The diary relates the measure of success that attended the undertaking, and gives a graphic picture of the daily life, sport and difficulties of the surveyor in such a country.

Purefoy Gauntlett Huddleston was born on April 28th, 1886, and was the son of T. F. C. Huddleston, Esq., of King's College, Cambridge. Educated at King's College Choir School and at Clifton, he passed into the Shop in 1904, and obtained his commission in the Corps on 16th January, 1906. He proceeded to India in 1908, and joined the Survey of India in 1909. In the first year of the War he was one of those R.E. officers in civil employ who were sent home.

Huddleston was a man of unusually fine physique, being 6 ft. 4 in. in height. When commanding the 84th R.E. Field Company (20th Division) he was killed near Ypres, on March 25th, 1916.

EDITOR, *R.E. Journal.*

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1. PREPARATIONS.

Nov. 16, 1912. On board S.S. *Iris*, tied up beyond Laimekuri on the way from Dibrugarh to Kobo. Party consists of self and 2 surveyors, Hamid Gul and Anwar Ali, and 11 khalasies (2 Gharwali, 8 Gurkha). Orders are to fill in blank between Siemen River westward to the tributaries of the Subansiri and southwards to Dijmur on 4 miles to 1 inch scale as far as possible. Captain Macdonald (I.M.S.) on board. Much talk of prospects of main advance afterwards, for which natives and coolies are being collected. Khalasies allowed 20 lb. of kit so far (10 lb. last year), self 2 coolies = 108 lb. (60 lb. last year) exclusive of office box and food.

Nov. 17. Arrived Kobo 10 a.m. Met Carter, who will command escort of 24 men. Kobo has a very fine stockade and look-out, but is hardly the hub of the universe as it was last year, with 3,000 troops in it. Stocked all unnecessary and extra kit in a *kamal* (godown), with 2 men to look after it. Ready for start to-morrow. Surveying

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P G. Huddleston

Surveyor Hamid Gul.

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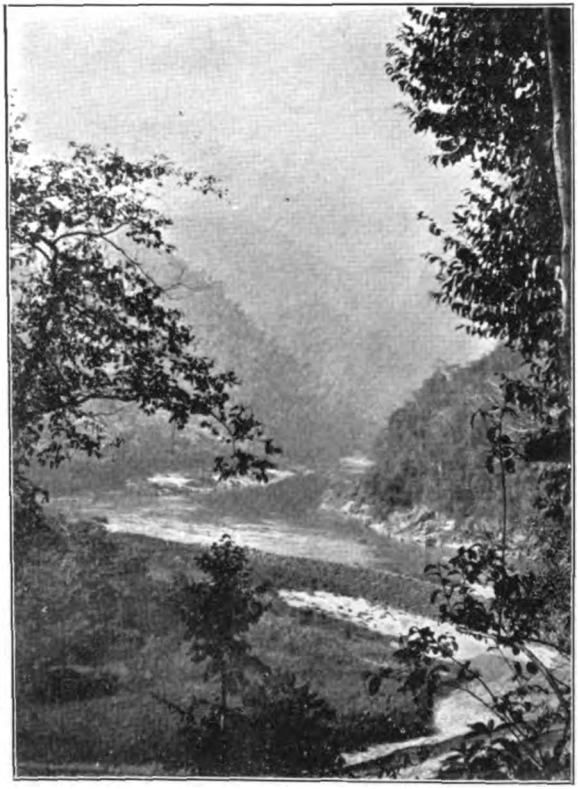

Dihang River from Rotung.
(About 10 miles below where Williamson was murdered.)

Distributing quinine.

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plane-tables both complete and ready for work. Porter to take Carter's place as commandant. Cheery dinner and much *bukhing*.

Nov. 18. Pelung, half-way to Pasighat and 12 miles from Kobo. The Abors who went up to murder Williamson were traced to a village near by. What a contrast to last year, where an army was proceeding cautiously along (true most unnecessarily cautiously), and now cartroad with telegraph wire, elephant carts and coolies plying the road at their own pace and without any escort; Abors working in the fields or the roadside. Surveyors and self got off 7 a.m., set up and checked last year's map to here. Large Abor clearings here and there, one 6 miles long, rest of the road through dense jungle. Found Dorward, quartermaster of the Lalchimur Military Police, in charge of the post of 50 men, making bullock and store sheds ready for shoving stores up for the main advance. Dorwood gave us dinner, as, though the 3 elephants arrived early, the carts did not get in till after dark. More *bukhing* about N.E. transfrontier and the numerous little shows that take place and never (thank goodness) get into the papers. Dorwood remarked casually that the other day two Gurkha sepoys who had gone out to *shikar*, not having turned up again after 3 days' continuous rain, were found both dead, lying with their heads on their rifles, out of which the last cartridge had been fired to attract attention. The jungle is so dense and dark that they had dropped in exhaustion quite near the post, after vainly trying to recover their bearings, and they were eaten to death by leeches.

Nov. 19. Decided to grow a beard. Got to Pasighat about 12.30, having left the surveyors to check and add to last year's map. Road 5 miles along a narrow clearing cut through virgin forests last year, and 5 miles through dense jungle with gigantic trees. Pasighat 514 ft. up, right under the Himalayas, where the Tsang-po comes through from Tibet (not much struck by its size). Hills of 6,000–10,000 towering darkly up back on either bank.

Met Furze, a very young Assistant Political Officer, who will administer the portion of the frontier. What a grand job! He has been here 7 months odd, hard at work clearing, stockade already built, getting ready for a bazaar, and building school and hospital. Post consists of 80–100 men. Another post at Balek, half-way up the hill near by. Watched Abors clearing, getting 4d. a day. Took photos. Made *bandobast* for to-morrow's march. Both Furze and Carter realize that this tour is chiefly for survey work, and everything should go well, though we are all very young, self senior by 2 years. When the Abors do not come in to work quietly, Furze sends them out a single match, a hint that their village will be burnt.

Nov. 20. Camped just outside Lalum on a stream where the footpath crosses it, in a space 25 yards square cleared from the jungle. By Jove, life is worth living! Arrived 4 p.m., cleared

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space. Built sort of wall of spiked sticks as perimeter, *bashas* (huts) of bamboo and banana leaves and waterproof sheets. The precaution is quite unnecessary, but it is as well to get into the way of doing it every evening, though the Galongs are likely to be most friendly. The Minyong Abors we are among now have learnt their lesson. However, last year, in the Miri mission they got careless up the Subansiri, and were rushed one morning while everyone was doing odd jobs, and if it had not been for Captain Graham, in charge of the escort, bowling over 5 men with his first 6 revolver shots, things might have ended nastily.

Got off with the surveyors about 7.30, leaving Furze and Carter to load up the coolies, 112 loads altogether. Offered an egg by an old lady in the first village, who asked if she might dance for me for a rupee. She also showed me the jungle cotton plants of which they make their cloth. From here magnificent view of the Mishmi snows. Set up again at Balek Post (100 men odd), 2,000 feet up and down and up and down and up to here 900 feet. An Abor runner brought our letters in. Extraordinary how cheerfully they take to becoming members of the British Empire, and yet they have been top dog in these parts for years.

Nov. 21. Camped in river-bed just below Barmin. March of 10 miles odd, 7 a.m. to 4 p.m., along foothills and down and up river-beds all the way. Set up at Yagrung, where Furze had the Abors singing and dancing to him in 5 minutes. Set up also in field below, and for 3rd time below Baring. Saw some ½ to ¾ lb. fish and an Abor (I'm picking up a little of the language) tells me there are big fish in the rivers ahead.

Nov. 22. Camp at Ledum. Could only go 4 miles as different lot of coolies must do next march. Late getting off, as surveyors did not realize the necessity of tying up their kits in the same way every day, so as just to be neither under nor over a coolie's load of 60 lb. Got into the road to Laimakum. Stung twice by small bees, and, on khalasies lighting a fire to drive them off, lit the bamboos by mistake, and we were precipitately driven off the hill. However, the hill burnt itself out in half an hour, and we then got quite a clear view above appalling jungly country with no villages. Ledum Abors very friendly. Drank a sip of their native drink, *apong*, like cider and not at all intoxicating. Glad I spent a few hours over the grammar in Shillong and Dibru, or I should have been held up to-day, as we have only one interpreter.

Nov. 23. Camp Doshing. This is a new village. The old one was burnt last year. March to-day only 8 to 10 miles, but pretty stiff going. Path either through a hole in the jungle, or through high grass or up and across river-beds. Wonderful country. Beats anything I have seen yet. The ascent to this village out of the *nullah* bed was unique, approached by an Abor ladder, a notched tree-

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trunk. Last year, the Abors might have made a successful stand here, but they only discharged a few arrows and bolted. The Doshing *gâm* (headman) did not come out to salaam Furze, but the sight of the rifles soon brought him to his senses. It was not worth risking having their new village burnt. Two sepoys down with slight fever. Weather looks doubtful. Raining hard.

Nov. 24. Kaking, the first Galong village, and the reception not as friendly as we had hoped, chiefly because it is the first time they have had to do anything for anyone but themselves. Village on a sort of pinnacle with cliffs all round, approached by one striding edge, across which they had a permanent stockade of spiked bamboos with a spiked door. Quite like ye ancient times. Got a fixing at Doshing, then 4 hours' grind up a bare hill off the path from which we were able to cut in a lot of the hills of the unexplored portion. I was able to suggest plans for the future and discuss them with the village *gâm*. I gave him pencil and paper, and he really made an excellent effort at explaining the position of the villages, and got quite excited when Furze said I had been sent by the English King to fill in the blank places on the map. Difficulty about a pig. They would not sell.

Nov. 25. Koiyu. Same reception. Very friendly. Interested to see our survey things, etc. Gave me a *salami* of two chickens and *apong*. But as for giving our coolies rice and carrying our loads for fair prices and wages, they don't see the point. March similar to yesterday. Camped in bottom of Siemen River. Villagers sent into fits of laughter by looking through my binoculars.

Nov. 26. In camp in mid-jungle up the Gag Pain. To-day disappointing. We had all wanted to do a round, which would have taken us completely through unexplored country, and brought us back on the unexplored portion of the Siemen River two marches below Koiyu. However, Furze had to take 20 sepoys up to the village this morning and insist on their providing rice, and he did not want to ask for coolies and be refused: and since the same friendly but unhelpful attitude might be continued at the villages ahead (all of which we could not burn) it was better to leave this rather ambitious *chukka* out of the programme. When you have 116 coolies with you, savages who last year were fighting against you, who have to be fed by the village of another tribe (Galong Abors), it is best not to be too ambitious. So Hamid Gul and I are off with 5 khalasies and 6 Gurkha sepoys, 12 Minyong coolies for carrying kit and our and their food for 4 days (no villages near), also 2 Galong guides. To-morrow I hope we shall get up the 5,540-ft. hill above and be able to cut in new country. The hill is densely jungle-clad, and we may have difficulty in finding a spot to clear. Anwar Ali with a similar party has gone off equipped for 4 days to try and get some similar hills on the other side. With luck we may between us be able to cut in most of the

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unexplored part, and by a similar trip lower down, finish the rest. The Siemen is swarming with fish (? *mahser*), ½ lb. to 3 lb., and I expect bigger. I have never seen such deep green, rocky pools so stocked with fish, and of course I have neither my rod nor the time to pull them out. The scene at the moment is fascinating. A flat space on a hillside of 10 sq. yards cleared out of the jungle alongside a roaring cascading torrent; the sepoys and khalasies singing their weird and very pleasant chanting songs over the fire a few yards in front of my little hut for the night; the savages just outside the perimeter round their fire, and the full moon hardly forcing its way through the trees.

Nov. 27. As I expected to have a hard day or two the khalasies, Hamid Gul, and myself shared with the sepoys one hour's watch each through the night, not from any idea of attack, but in case any of the coolies might take it into his head to steal anything. Though they seem to be the most simple-minded children, and I find no difficulty in making them roar with laughter at the smallest joke and keeping them cheery and happy. Started off at 6 a.m. and the path (to Nomdir) led straight up the hill face, a steady rise of 45° from 1,500 feet to 4,700. The pass, to my chagrin, turned out to be a double one, and broad, with no possibility of clearing it. Hence there was nothing for it but to cut a path along the ridge to the west till we could find a suitable place to clear, and after an hour's hacking through undergrowth and bamboo clumps we found the end of a spur, from which, after 2 hours' clearing, we got as decent a view as I could reasonably have hoped for. Might have been better: might have been much worse. We saw practically the head waters of the Siemen River and Doji village on the Sipu River, which goes into the Siyom. Hamid Gul was able to sketch in approximately the divide between the Subansiri and Siyom tributaries in this corner. If we manage to get up a hill 5980 within the next week, to-day's work will be most useful. Also fixed the village of Sago at the head of the Siemen River, where the Galongs said no village existed. Early dinner and to bed, being the first day that I can say I have been the first white man to see another new piece of this old earth of ours.

Nov. 28. Left Gag Pain camp at 6 a.m. and going very fast reached Koiyu at 9 a.m. Off again with Carter and Furze and all the kit by 11 a.m. Met 10 armed Galong *en route*; it appears they are on the warpath over some dispute about their fields with the neighbouring village. Camped just short of Kadu. Anwar Ali arrived this evening, having failed to get a clear view from his hill.

Nov. 29. Started at 6.30 with Furze. Found road closed by various signs *en route*, which looked suspicious, but turned out to be only a warning not to bring sickness into the village. Villagers came out to meet Furze with chickens and eggs. I have decided to do a *chukka* with light kit from here.

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Nov. 30. Daring. Circumstances rather trying, as the *gâm* and villagers insist on sitting round in a circle and gazing at me. Interrupted by giving the children a game of choosing which hand the prize was in, and then Heads and Tails. Now I have finished my tea and most have gone. Considering that no *sahib* has ever been here before, no wonder they are interested.

Left Kadu early with Kaking the *gâm* as guide. Got an excellent fixing for Hamid Gul for the new country. Halted at Tarking (4–6 houses) and saw Jorgi (10 houses), got into Daring about 3 p.m., where, to put it mildly, my reception was most warm. They wrote down my name with much pleasure as being the first *sahib* to visit their village. They gave me eggs and chickens, and I drank rum with the head men. I agree with Furze that no opium should ever be given, but I don't think that a little rum in return for their *apong* does any harm. What with the compass, my binoculars and various other parts of my kit, I had no difficulty in giving them a two hours' pantomime. They contributed by a small boy stark naked dancing a sort of Irish jig. Daring is a thriving village of 60–100 houses. Country less precipitous, jungle less dense and many fields. People doing well. Headmen can talk Assamese, and often go into Dibrugarh, 3–4 days' march, over the hills, not by the Siemen River. Kaking goes back to Furze at Ripon, having got me two guides from this village. My party now consists of self, Hamid Gul, Unwar Hassam (cooking for us both), 4 khalasies, 6 sepoys and 14 Abor coolies.

Dec. 1. Started 7 a.m. with a triumphal procession. The old *gâm*, Kaking, came out of his house with a dirty old *solar topee*, which he proudly said had been given him by the Dibrugarh Deputy Commissioner. He and his brother *gâm* insisted on accompanying me to the Ego River, which to our surprise was as big as the Giri below Solon. Leaving the coolies on the beach we went up a 2,000-ft. hill near by, passing through Lalu village, where I drank their *apong*, and was given more eggs. From the hill we got an excellent view of this unexplored corner. Took heights and selected the hill to be climbed to find out the watershed between the Siemen, Subansiri and Siyom. Showed it to the Abors, and then the difficulties began. "No road, all jungle, etc." "For the map's sake *jubbi luggi* (= *jâka lâge*, must go)," say I. "No, *sahib*, there is a village there which is ill, and all the roads up the Ego River are closed." "*Jubbi-luggi*," say I, and eventually, after many more stern *jubbi-luggis*, we reached the coolies again and started off. At the last moment old Karking, who is rather an old brick, said he must come too, in case we and his nephew (one of the guides) should die. And here we are, 2 miles short of Pading, having come by an excellent path along the Ego River bed and have left the sick village (if it existed) up a side stream. News had been sent by some men we met fishing to

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Pading village ahead, and after dark some 8 men with their *gâm* came in with *apong* and chickens and eggs as presents, and seemed very pleased and excited to see me. They repeat there has never been any trouble in their country (referring to Williamson's murder by the Minyong Abors), and they are only too pleased if the Sirkar will send *sahibs* to visit them and see their country. Amused them with my acetylene lamp and, to their immense delight, gave them a candle to go home with. Women and children crowd round at the villages, and I am taking practically no precautions, except my shotgun, which I always carry myself. Shot a small eagle to please them to-day.

Dec. 2. Most successful day as regards more country sketched. Started directly it was light up the river path, very good, passable all the way, except in one or two places, from Taking to Pading. Met by Sissi villagers (16 houses) *en route* and given *apong*. Pading largish village, 20–30 houses, evidently expected, reception very friendly. They suggested best hill to go up. While waiting for guide, noticed an old man abusing Daring *gâm*, who looked frightened. Something wrong. We proceeded towards the hill, but they said "No, no, we must go to another hill." Coolies looked nervous. After some discussion I agreed (as it turned out luckily) to go up the other hill, and we got an excellent view of the head water of the Ego River. Fired off my shotgun at a mark to show them. The old *gâm* got me to write something on a piece of paper, about which he evidently made up some lies while haranguing the villagers, and seemed mightily pleased when we got out of the village. Unfortunately, what with the sepoys talking Gurkhali, the Galongs their own language and a little Assamese, the Minyong Abors their dialect, quite different again, and Hamid Gul Hindustani, it was impossible to find out what the trouble was, if any. It seems that some of the villagers did not want to give the Minyong coolies food, in fact disliked their being there at all. Evidently there is no love lost between the Minyongs and the Galongs, the former having been top dog for years and years. The chief drawback about this pleasant corner is that the Abors here take opium and have the attending greed for money.

Dec. 3. Camp Talu, on the Ego River. Path very bad up and down all the way over a jungle of wooded hills all 1,000–2,000 feet high. The last mile is down an extraordinary fissure which a small tributary of the Ego has cut for itself, breadth at bottom 10–20 feet, and sheer walls of rock 100–200 feet on either side. Side fissures coming in on both sides. Absolutely unique. The Ego is tantalizing. Throw in a stone and both *mahser* and Indian trout 1–5 lb. dash up to see what it is, like throwing bread into the sacred pool at Hardwar.

Dec. 4. Ascended the hill 3,510 feet above, cut a path up the last 1,000 feet almost sheer, and if it had not been for the creeping trees growing in the rocks I doubt if we should have got up. Anxiously

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cleared the hill and got quite a decent view, and saw for the first time through a broad gap the 15,700-ft. hill, 100–120 miles off. By Jove, magnificent! A perfect pyramid without a cloud on it. Also got a good view of the Brahmaputra standing out like a long, thin lake with many islands across the plain. Talu village of 20–30 houses seems to thrive, but it is a dead end, impossible either to get up or down the Ego gorge. The only path as far as the villagers will tell me is up the fissure of yesterday. Goodness knows what they do in the rains.

Dec. 5. Camp Ripon with Furze and Carter again.

Path from Talu to Siemen practically up and down stony ravines and gullies and water-courses the whole way, finishing by swimming ford, impassable after rains.

Dec. 6. Camp at Peyang village (burnt last year). Checked Hamid Gul and Unwar Ali's work. Former excellent. Latter needs checking.

Dec. 7. Camp Korang. First-rate morning. Still working at Unwar Ali's board. Country south of Korang and Peyang is a mass of ravines and jungly hillocks. Very intricate surveying, and I think I cleared the contours rather successfully. Korang, also burnt last year, has not come in properly yet. A little durbar to-morrow will no doubt make them understand the British *régime*.

Dec. 8. Furze's little durbar duly impressed Korang villagers, and they now understand that they are citizens of the British Empire.

Dec. 13. Went fishing in the afternoon. Eventually got a 38½ pounder on a *chilva* imitation minnow. Best previous fish 22 lb. 4 years ago. Topping. Took ¾ hour to land. Not a bad christening for my new split cane rod.

Dec. 16. Went down the Dihang to Kobo in dug-out, doing a time prismatic sketch *en route*. In the morning the river was alive with cormorants and fish-eating eagles. An eagle would spot a cormorant which had a fish in its feet under water, and chase it till the cormorant dropped the fish, and off went the eagle with the fish in its beak. Suddenly my boatmen started chasing one of the eagles, and as he couldn't fly fast with a fish in his bill we gained on him, and he in his turn had to drop his prey, but the fish got away before we got there. Then the boatmen spotted a solitary cormorant; it dived; we gave chase; it dived again, we getting nearer every time, till we were within 20 yards. It then flew away, and the boatmen with a triumphant yell seized a dead ½-lb. fish out of the water. What a fascination these big rivers of this corner of India have, with their dense jungles on either bank, their little villages of boatmen, their rapids which are so glorious to shoot, their shoals which you have to punt over like the old Granta up to Byron's Pool, and their superb sunsets over the sandy islands.

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In Kobo things are getting a move on. The 2 Macdonald doctors, Pemberton with his ½ company of Sappers and Miners, Musson running the supplies up, and Boyce with his mule corps, 700 strong, which will work between here and Roking; one man per 3 mules. This in itself has cost the Government £6,000 odd, including their food for two months.

Kobo up to last year was a little Miri village in a wee clearing in the dense forest. Now it is all agog. There are the ducks in their pond, the goats, the rows of huge sheds filled with bags piled high with rice, flour and the various foods of the different castes of combatants. Then there are the coolie corps, 850 Gurkhas and 850 Hushauts (the latter a tribe that would compare with the Abors 10 to 20 years ago), putting up more sheds, barracks and officers' bungalows. There is the inevitable Indian *buniya* (merchant), objectionable but most useful, who is starting a little shop for trade, and will cash you a cheque for £10 at sight.

* * * * *

Dec. 24. Took khalasies for constitutional and accompanied Furze 3 miles down the river to where some sawyers were sawing up *horal* trees. About 10 years ago, during the rains, the Dihang distributed these trees, a very fine kind of cedar, all along its banks. Though it is not known exactly, there must have been a big landslip up in Tibet, which made a dam, and when the dam burst, down came these splendid trees, together, the villagers say, with dead Tibetans. And there we saw the trees to-day, lying in dense, damp jungle along the river-bank. Huge trees 6 feet in diameter, beautifully seasoned and smelling like a bottle of sweet turpentine.

Dec. 25. Christmas Day. Pasighat. Worked at computations. Went fishing. One 16, one 10 and one 3½ lb., at any rate enough for my share of the dinner as ordered. Played Association football against the sepoys till the bladder burst. Most cheery and excellent Christmas dinner. Porter did some very clever conjuring and sleight-of-hand tricks after dinner. Others bridge and I to bed.

(*To be continued.*)

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THE ORDNANCE SURVEY IN RELATION TO WAR.

By BRIGADIER E. M. JACK, C.B., C.M.G., D.S.O.

IT is common knowledge that the application of survey to military operations developed during the Great War to an unprecedented extent. This development took place in the actual survey and printing in the field of maps of the front line region and of enemy territory; in the use of air photography as an aid to this survey; in the production and scientific use of large scale gridded maps; and in the utilization of survey as an aid to artillery work. There is no reason to suppose that the hopes that mobility will be greater in the next war than in the last have in any way decreased the importance of maps and surveys. In fact the difference in the pre-war and the present outlook may be gauged by the fact that before the War the bulk of the personnel of the Survey Companies was allotted on mobilization to other units, it being held that there would be little or no call for survey work in war time; whereas now the whole of the Survey Battalion (as it now is) is allotted for survey work on mobilization, and the Director General is made responsible for survey training for war.

The functions of the Ordnance Survey and its relation to war requirements are little known, and the present article is the result of a conversation between the writer and an officer who is keenly interested in the matter, and who suggested that Royal Engineer officers would welcome information on the subject.

As a preliminary, it will be as well to give some account of the employment of Royal Engineers on the Ordnance Survey. The latter is a peculiar institution. It started as a purely military body, with the object of producing a 1-inch to the mile military map of the Kingdom. Very early in its history civilians were engaged to supplement the military, and the production of large scale maps was later added to its duties. With increase in numbers, the civilians came in time to outnumber greatly the military. To-day, the Ordnance Survey is a Civil Department, under the Ministry of Agriculture, but it retains a good many of its original military characteristics. The direction has throughout its existence been in the hands of military officers, and of Royal Engineer officers since 1820, when Colby became Director.

The subordinate staff of the Ordnance Survey consists partly of serving Royal Engineers, partly of civilians, a large proportion of

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whom are ex-Royal Engineers. The career of a Royal Engineer who serves on the Ordnance Survey is usually as follows. Lads are engaged, from 15 to 16 years of age, on condition that they will later enlist in the Royal Engineers. (Formerly no condition was made, but at present the Royal Engineers are much below strength, and the civilians above, so that recruitment is now being done only through the Royal Engineers.) They are given instruction in field surveying, drawing, and various Ordnance Survey duties. At 18 they are enlisted and sent to Chatham, where they do the usual recruits' course of one year, and then return to the Ordnance Survey.

There are certain exceptions to the above method of recruiting. Some boys are taken on at an older age, up to about 18, under special provisions; and some recruits are obtained by "direct transfer" from other branches of the Royal Engineers. These are men who apply and show special aptitude for survey work. They are specially selected by Commanding Officers of units, who have been notified by Colonel i/c. R.E. Records of our requirements; they are taken on probation, and if satisfactory after a year's service they are retained.

Once started on their military service on the Ordnance Survey men complete their six years with the Colours, extend to complete twelve, and then re-engage to complete twenty-one years. They then retire with a military pension, are re-engaged as civilians, and serve until the usual retiring age (60) for the Civil Service, when they get a further pension based on their civilian service.

Royal Engineers are employed on the Ordnance Survey on various duties according to their aptitude. At the beginning of their service they usually go to a Field Division and are employed on the revision of the 25-inch map. Those who have a talent for drawing will later be brought into the office. Some pass most of their time in the Levelling Division, and others again, who have previous knowledge or have a leaning that way, go to the lithographic side, and become lithographic draftsmen, provers and machine minders. Lastly some are employed as photographers, or in the allied trades of photo-writer, or workers in the helio and vandyke processes.

Few Royal Engineers however pass their service without some experience outside the Ordnance Survey. There is a constant demand from the War Office and from Colonial Governments for the services of trained surveyors, and it is usual for 50 or 60 men to be absent abroad at any one time on employment in various Colonies and Protectorates. Such tours abroad give very useful and varied experience. They are counted as part of their service, and men return to the Ordnance Survey at the end of them.

The conditions of service enumerated above show that a Royal Engineer, provided he be a good workman and of satisfactory character, has a career for life on the Ordnance Survey, with good pay

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and a pension at the end of it. If a man's behaviour is in any way unsatisfactory the Director General, who has very wide powers, can get rid of him at the end of his first period of engagement, or at the end of his 12 years, or he can refuse to re-employ him as a civilian. It is, therefore, difficult for an inefficient man to remain on the Ordnance Survey. In addition, the good prospects and security of employment make competition to get on the Ordnance Survey very keen. A good stamp of boy presents himself: selection is by qualifying examination, enquiry, and personal interview. The result of all this is that the standard of men employed on the Ordnance Survey is very high.

We must next pass to the nature of the work done on the Ordnance Survey. The great bulk of this work is, and has been since the completion of the original survey, the revision of the large scale map (scale 1/2500, or 25 inches to the mile as it is commonly called). This revision is the basic work of the Ordnance Survey, and is the employment of the large majority of the staff. The method of revision in the field is based on the assumption that the original survey was of a high degree of accuracy, an assumption which is justified when it is remembered that it was entirely a chain survey, that is to say carried out by actual measurement on the ground.

The reviser takes with him in the field a portion of the existing 25-inch map, about 12 inches square, carried in a special form of case. It is his business to satisfy himself as to all detail which has not changed since the last revision, and as to all changes and additions. Having verified the old unchanged detail he uses it as the basis for inserting the new, which he does by prolongations, intersections, and measurement by pacing or by tape. He has various methods of checking his work. A trained reviser will carry out a revision by these methods with great accuracy.

In some cases where changes are considerable (as in extensions to towns), and there is little old detail on which to fix the new work, some assistance is necessary in the shape of points fixed by a small triangulation, or by a traverse.

These methods of working have an important bearing on training for war. The idea has been held by some that constant employment on this type of large scale survey is useless as a preparation for the survey duties required for war. If the men were employed on chain survey there might be some truth in this; but that work (the original survey) was finished years ago. The revision work described above is as a matter of fact a peculiarly good foundation for plane-tabling. It trains a man to habits of accuracy; it keeps keenly alive his survey sense, that is, the sense for placing details in their correct relative position on the map; it makes him use methods which are in some cases identical with, and are always akin to, those required for plane-table work. In one respect however it gives him no training, and

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that is in the representation of ground forms. The Ordnance Survey reviser is an accurate maker of plans, but of plans only, without relief.

After revision in the field comes the drawing of the revised map in the office. This work gives training in drawing on a large scale; it teaches neat penmanship and accuracy. On the whole it may be said to provide a good foundation for the drawing required in war; and is certainly excellent training for drawing for reproduction—an important point.

But while many men are employed on drawing the large scale 25-inch map, and its product, the 6-inch map (which is drawn on the 12-inch scale and reduced by photography) a considerable staff is engaged on small scale drawing of the 1-inch and smaller scale Ordnance Survey maps, or on the 1/20,000 and similar scales for the War Office. This class of work is practically the same as that required for war.

Of the publication trades (*i.e.*, the trades required for map printing), namely lithographic drawing, proving, printing, the making of negatives and zinc plates, the correction and retouching of negatives, etc., little need be said. This class of work is practically the same as would be carried out in war, the difference being in certain points of equipment, and in the conditions of working which are inseparable from active service.

The above general and rather brief description will it is hoped show that the normal work of the Ordnance Survey provides at any rate a good foundation for the work a surveyor is expected to do in war. But much more is obviously required. Further training in the technical duties required for war is necessary, and, beyond that, training in the team work of a military unit is needed.

The first is provided by classes which are held throughout the summer every year. When it was decided that the men of the Survey Companies (now Survey Battalion) were required for survey duties in war and for no other duties, and when the Director General of the Ordnance Survey was made responsible for training in such duties, the annual field works course was abolished and was replaced by courses in military survey duties. Courses are held, from April to September, in trigonometrical and topographical surveying, both preliminary and advanced. Each course lasts a month, and includes about 30 men. In addition to the technical courses, drill and musketry has to be included in the training season; and a special drill and duties course is always held for young non-commissioned officers.

Courses are held during the winter in topographical drawing, and in air photo work; while training in trigonometrical computing, besides being included in the trigonometrical courses, goes on all the year round in the Ordnance Survey Trigonometrical Division.

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The above technical training, during the progress of which the men are paid by the War Office, is based on one-third of the strength of Royal Engineers being trained each year. On the face of it, it would appear that no man can go through a course more often than once in three years, but practically, owing to the fact that men of the publication trades do not have to do annual courses, it works out more frequently than this. Even so, the training is slower than one could wish; but it is a compromise between what is desirable and what is practicable. The " war trades " are classified, and promotion depends on them to a large extent. That is, apart from other qualifications, no man is recommended for promotion unless he has attained to a specified proficiency in various war trades, according to his rank and the employment for which he is fitted.

A man who has gone through a series of courses in war trades may be described as a trained man; and if in addition, as is frequently the case, he has done two or three years of practical work in a Colony or Protectorate, he is an experienced surveyor. It was men of this type; men, many of whom could turn their hand to almost any kind of survey work required—observing, computing, plane-tabling, drawing—and all of whom were expert in at least one branch, who formed the backbone of the Field Survey Companies during the War, and without whom the excellent survey organization that was developed would have been impossible, or at any rate would have been seriously delayed. The same type of men are available now, but the needs have greatly developed. Royal Engineer surveyors have now to take their place with other troops immediately on mobilization, or in peace time on manœuvres or exercises; they have got to produce results, on which other work will depend, at short notice and often working against time. This brings us to the necessity for team training, or training together as a unit.

This training has been provided hitherto by annual exercises, which have been held every year for the last seven or eight years. These exercises have been carried out mostly in conjunction with the School of Artillery, but some have been done by the Royal Engineers alone. The exercises have been done on the usual lines of a military situation which developed as the scheme advanced, and with definite problems to be solved. The Royal Engineer Sections which took part in these schemes (Topographical and Drawing Sections) were necessarily formed *ad hoc*. The men were assembled usually a few days in advance, and were together during the exercise for about a week or ten days.

However good the material of which these sections was composed, (and it was first-rate material) it will be obvious to any soldier that sections formed under these conditions could not be wholly efficient at first, or indeed within the short time the men were together. It has never yet been possible to assemble a complete war unit, fully

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equipped. The machine was made of good stuff, but was bound to work stiffly. It must be remembered that a great deal of Royal Engineer Survey work in war must be done in close conjunction with the Artillery. The Royal Artillery have taken up Artillery Survey very keenly. They maintain a full-sized unit, the Artillery Survey Company, which is at work on its own problems all the year round, and Royal Artillery surveyors are, within the limits required for their own work, highly expert. It can be imagined that it was something of a strain for an R.E. Section, gathered from all parts of the Kingdom, and working together as a unit for something less than a fortnight, to keep its end up. That they have managed as well as they have done is a great tribute to the personal efficiency of both officers and men ; but it became increasingly apparent that existing methods of training were not adapted to present requirements, and that to make men efficient as a unit continuous training as a unit was essential.

The same conditions apply in the case of the publication trades, lithography and photography. Though men in these trades are employed the whole of their time on them, and hence are individually expert in the duties required for war, the conditions of working on the Ordnance Survey are very different from those of active service. The transition from peace to war duties is in their case in some respects marked by less change than in the case of the topographical trades, but the need for unit training is no less urgent.

Proposals were accordingly put forward that a portion of the Survey Battalion should be detached in the form of a "Training Unit," which would be continuously employed in war duties throughout the year. Men would pass through the unit, spending a period of say two years in it, and returning to their Ordnance Survey duties at the end of the tour. The unit would consist of Sections organized on the lines of War Establishments, *i.e.*, Topographical, Drawing, Lithographical and Photo Sections, fully equipped ; it would be occupied on training and productive work throughout the year, and would be available when required for exercises or manœuvres.

The necessity for some such unit has now been officially recognized, but, for reasons into which it is unnecessary to enter here, it has not yet been possible to bring it into existence.

The proposal is, however, still under consideration, and the interest in this question has increased to a large extent. There seems a possibility that a unit may be authorized that will be far larger than was originally contemplated or thought possible.

That, however, lies in the future, for the formation of this survey unit must take time. The Ordnance Survey is a busy Department, performing important public functions, and it has to carry on the work for which funds are provided by Parliament. It is impossible to detach a large body of men suddenly from it without dislocating its

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work seriously. The unit must be built up gradually, and it will take some years for it to reach completion. But that a Royal Engineer Survey Company, or organized and permanent unit of some sort, will be in existence in the course of the next few years is I think certain.

And the need for this, apart from the technical and training reasons which I have given, is urgent. Survey is now a serious and indispensable weapon of war, which being new requires study, practice and research. The Artillery have ever since the War accepted the fact that a knowledge of survey is essential for their work. The adoption of survey methods has already had a profound effect on artillery tactics, and is not yet at the end of its development. The demand for accurate maps is greater than it ever was. Yet the Royal Engineer surveyor who lays the foundation for all this work is hardly seen by the Army, and seems sometimes to be forgotten. When the " Survey Company " is mentioned soldiers think naturally of the Royal Artillery Survey Company. This is hardly surprising when the Royal Engineer Survey Company—or a very small portion of it—materializes only once a year for a few days. It is time that a Field Survey Company R.E. took bodily shape in peace time and was available for other troops to see. It is further important that other troops should learn to use the products of the Field Survey Company efficiently. The tactical use of survey is new, and requires working out, so that each party may know what to do and what to expect of the other. There are numerous practical and technical problems for the solution of which there has been little opportunity up to the present, and for which there can be little until an R.E. Survey unit, working full time, is in being.

I have endeavoured in this article to show how the Ordnance Survey provides for the survey requirements of the nation in war. I have tried to show that employment in peace time on the Ordnance Survey provides good material for making the military surveyor (incidentally at no cost to the Army Vote), and that the special training given goes a long way towards making good military surveyors. Finally, I have pointed out that some further provision for military training is needed, and how it is proposed to provide this.

What I have said refers, however, to the rank and file. The training of officers is a different question. The survey course covering the principles and all the most important methods of survey, which Royal Engineer officers get at the School of Military Engineering, makes it easier to give them the specialized training which is required for survey in war. On the other hand, the fact that junior officers stay only a short time on the Ordnance Survey and have large administrative responsibilities makes it difficult to find much time for war training. The tour of a junior officer on the Ordnance Survey is nominally five years, but that period is frequently cut short by calls from the War Office for officers for Boundary Commissions, and

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Colonial and other surveys, with the result that the average period of service on the Ordnance Survey of officers below field rank during my directorate has been three and a half years. Employment on practical survey abroad is the best technical training officers can get, and is always encouraged; but it is not training in war duties. Courses are held periodically, mainly for technical training and refreshing; and officers take part in or are attached to all exercises. But a good deal more is needed, and this it is hoped will be provided by the Field Survey Unit which is contemplated.

Earlier in this article I said that the Ordnance Survey was a peculiar institution, and that statement will bear repetition. The Director General acts in a dual capacity. He is the Director of a civil Department, and responsible to the Minister for Agriculture and Fisheries for its efficiency, and for carrying on its work, which is the maintenance of the survey and maps of Great Britain. He is responsible to the War Office for the efficiency of the troops under his command, and for their training for war duties. Strictly speaking, he is responsible for these also through the Minister for Agriculture, but the Ministry leaves the Director General an absolutely free hand in all purely military matters, and correspondence and all arrangements relating to these are carried on direct with the War Office. As mentioned earlier, the Ordnance Survey started as a military institution, staffed entirely by soldiers; it has always retained a considerable flavouring of its military organization; and to-day, with its total establishment reduced to a little over 1,000, and its establishment of Royal Engineers increased to some 450, it will not be many years before the great bulk of the staff will be either serving Royal Engineers or ex-Royal Engineers.

The information given will I hope show that the Royal Engineers on the Ordnance Survey, though in civilian employ for most of their time, are by no means civilian in spirit. No man can hope for advancement unless he becomes efficient in war duties; no man can hope for the permanent employment which is the immense attraction of the Ordnance Survey unless he is thoroughly efficient at all his duties. As a result, the men of the Survey Battalion are a well disciplined, smart and efficient body, who I believe have no need to fear comparison with any other branch of the Royal Engineers.

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THE TRAINING OF THE TERRITORIAL ENGINEER OFFICER.

By CAPTAIN E. V. BOWRA, O.B.E., R.E.

A POLICY.

THE Territorial R.E. Commanding Officer has considerable latitude in the training of his unit. The only instructions which he gets to work on are brief paragraphs in *Engineer Training*, to the effect that the principles of Territorial training will be the same as for the Regular forces. These terms are so general that it is necessary that every unit, in order that progress in training may be continually maintained, should have a considered training policy, strong enough to survive the vagaries of successive commanding officers and adjutants and as the effective counterweight to a complicated administration involving much attention.

What is this policy to be? A policy for training for war must be based on the probable employment of the unit in war. A high authority has pointed out in the military press* that the Territorial Army is likely to be required either (*a*) as the foundation of a National Army, or (*b*) to supplement the Regular Army with composite units. It is evident that no T.A. R.E. field unit is likely to take the field just as it is in peace. In case (*a*) presumably a cadre would be thrown off on mobilization to form at once a second line unit. In case (*b*) selected volunteers would be required and arrangements would have to be made to train reinforcements. In either case the raising of sappers would not present great difficulty, but competent instructors and leaders would be an important essential from the outset. These men need not necessarily have high technical qualifications in civil life, but should be in positions of authority where they are already accustomed to leadership. They can then be made capable of organizing and training sappers in their military and engineering duties in the field. *It is considered, then, that the training of officers and N.C.O.s in their duties in the field is of the first importance and should be the definite training policy.* It should have primary consideration as regards expenditure of training grants. Administration should be simplified to the last degree so as to allow time and energy for its execution.

* *R.U.S.I. Journal*, May, 1928, "Some Territorial Army Problems," by Lieut.-General Sir H. Jeudwine, K.C.B., K.B.E. See also *Army Quarterly*, April, 1929, "The Territorial Problem," by Bt. Lt.-Col. H. E. Franklyn, D.S.O., M.C.

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Considerations in Training.

It so happens that the Territorial Army lends itself better to the training of the officers and N.C.O.s than it does to the men. The average man joins for four years, at the end of which time, unless he gets promoted, he usually goes. As there is no T.A. Reserve, he is then (militarily) lost. Even if he is keen and has put in more than his minimum of a hundred drills during this period (say 75 hours' actual instruction), as well as his annual camps and certain week-end trainings, the amount that can be taught is small, especially in a technical corps. On the other hand, if he is promoted, he will probably remain on and show increased keenness.

Senior N.C.O.s are permitted to re-engage up to the age of 55 years. Many do this and it is possible to put in as many as 37 years' service, earning the Territorial Efficiency Medal several times over and having one's sons serving in the unit! This long service system tends to a body of N.C.O.s in a unit too old to absorb or impart up-to-date instruction and blocking promotion, thereby discouraging the younger men. Keen young N.C.O.s are what are wanted in a company. They are malleable material, they can be taught a surprising amount in a short time, and if they can manage to get away on courses at the S.M.E. or with a regular company, soon become useful instructors, still active enough to take the field if required.

It is not intended here to discuss the training of N.C.O.s, but rather the more difficult problem of officers—from the point of view of "individual" training (as opposed to "collective" training at "drills" and camp).

The C.R.E. and his adjutant are confronted with all sorts and ages—some with war experience in the corps, some with war experience in other arms, some with no war experience; a few in the engineering profession, some in the cognate professions, some with little or no technical training. The time that these gentlemen will be prepared to give to soldiering varies, but it may be assumed that the average officer will attend at his drill hall one evening a week, on the average, throughout the year and will be able to give up half a dozen or so week-ends, in addition, of course, to annual camp. The officer has a day's (or a week's) work behind him on arriving for his Territorial activities, so cannot be expected to arrive fresh.

Courses with the Regular Army.

No training within the unit can take the place of attendance at a course, either at the S.M.E. or attached to a regular company. There are now no courses compulsory by regulations, but they can be strongly urged by (*i*) notifying applicants for commissions that they will not be considered unless they guarantee attendance at the six-weeks Junior T.A. Officers' Field Works Course at the S.M.E.,

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(*ii*) not recommending promotion to Captain until this course has been completed, (*iii*) not recommending promotion to Major unless the Captain's Course at the S.M.E. has been attended. If an officer positively cannot get away for more than a fortnight in the year, it is considered more important that these courses should be attended than that he should attend annual camp. In addition to the training, they give the young Territorial officer practically his only chance of liaison with the Regular Army and of broadening his military outlook. This is important for newly-joined officers with O.T.C. experience, but it is considered imperative for those joining with no previous military experience whatever.

A System.

The organization of the individual training of officers within the unit resolves itself into :—Practical instruction. Lectures. Week-end courses and exercises.

Practical Instruction.

Newly-joined officers should parade with the recruits and be trained by the permanent staff until they reach at least the standard of the practical portion for Certificate " A." If already in possession of Certificate " A " (All Arms) they need only attend field works parades for Certificate " A " (Engineers).

Riding instruction depends on the facilities available. An officers' class at camp is the simplest to arrange, but takes the officers away from the men during the short period they have of collective training. Recruit officers must be taught the elements of riding before they go to camp, if necessary attending the drivers' drills. For those in possession of their Riding Certificates a Sunday morning " jolly " is popular. If it is not possible to centralize the officers for this, arrangements can be made with the Territorial Association horse contractors to provide an officer a horse on demand. A proportion of the Association horse hire grant for riding drills should be definitely set aside for the training of officers.

Lectures.

These are arranged most conveniently during the winter months and may be divided into (*a*) the " general," (*b*) the " particular." The " general " should be a short course for all officers, not more than one a month for the six winter months but all officers are expected to attend. They should be on interesting subjects and may well be on broad lines, *e.g.*, modern R.E. developments, mechanization, horse management, army organization and administration, Corps history ; though it is as well, occasionally, to treat of practical peace-time subjects, such as keeping accounts and stock-taking.

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The " particular " embrace the instruction necessary for officers' examinations. That with the most failures (although only a schoolboy examination), and the only written one, is Certificate " A " (Engineers), which officers have to take within three years of joining, in addition to Certificate " A " (All Arms), if not already in possession. Proper coaching is essential, more especially for candidates for the All Arms paper. A series of six weekly lectures is considered the minimum, including plenty of time spent on the sand model and on map reading. Training at drills and at camp should largely cater for the Engineers' paper, but a few lectures are necessary to ensure covering the syllabus. The candidates must be taught exactly how to tackle a written paper. They should understand that lectures are not sufficient and be given a syllabus of reading to supplement them—the official syllabus is extensive and the average officer is not able to find time to study the whole of it. Instruction is necessary also for candidates for (*f*), (*a*) and (*c*) examinations for promotion. If units have detachments so dispersed that officers cannot attend for personal instruction, that for examinations has to be carried out by correspondence.

It is useful to type out the " meat " of a lecture, together with the appropriate references to the manuals, and give every officer a copy, which he should put away for reference in his " Territorial File." A lantern is a useful adjunct to brighten lectures ; a collection of slides can gradually be made, covering a variety of subjects. A cinematograph machine is an asset ; for the full-size kind, reels of various subjects can be obtained from R.A.O.D., Aldershot, but the Cine-Kodak type is more likely to be used in the future.

Week-end Courses and Exercises.

A week-end course of practical instruction can be arranged to take place at drill halls, more especially if these happen to be provided with cooking arrangements and sleeping accommodation, if required. It is not always easy, however, to provide an attractive programme, and a week-end exercise at a selected hotel is more of a draw and gives more scope.

The best time of year for these exercises is in the " quiet " season and when the days are still fairly long for out-door work, *i.e.*, in the autumn or early spring. They have the advantage of getting together all the officers of a unit and opportunity can be taken of holding officers' conferences and general mess meetings. The " autumn meeting " gives an opportunity to discuss the unit's winter training and winter entertainments and sports programmes. The scheme can usefully be made to rub in lessons learnt at camp before they are forgotten, thereby ensuring continuity in training. The " spring meeting " is important in order that all officers may fully understand the proposed summer training programme—the scheme can usefully

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introduce subjects in connection with it; dates suitable to the majority may be fixed for week-end activities. A further advantage is that the half-yearly Certificate "A" and promotion examinations are held at these periods and the exercise can act as a "refresher" just before them.

The decisive factor as to how many exercises should be held is the training grant. Considerable economy is effected by officers drawing travelling and detention allowances to cover their expenses, but no pay. Officers are usually willing to use their cars without claiming mileage allowance. This excellent "voluntary" spirit should enable at least two exercises to be held in the year, in addition to an officers' and N.C.O.s' combined exercise.

To make the week-end popular, officers should not be worked after dinner on the Saturday and they should finish early enough on the Sunday to start for home by daylight. If given ample notice, they can usually get off work early enough to travel on the Saturday morning. Those who play games on Saturday afternoons should understand that Territorial duties should have first consideration. The following has been found to be a useful working programme :—

Saturday.	1.0 p.m.	Assemble for lunch.
	2.0 p.m.	Issue scheme.
	5.30 p.m.	Conference on afternoon's work.
	7.0 p.m.	Break off.
Sunday.	8.30 a.m.	Breakfast.
	9.30 a.m.	Carry on with scheme.
	1.30 p.m.	Lunch.
	2.30 p.m.	Conference on day's work.
	3.30 p.m.	Conference on training programme, mess meeting, etc.
	4.30 p.m.	Break off.

The setting of the scheme is no easy matter when dealing with so many varieties of rank and of attainments. The following types have been found to be of some value :—

(*i*) A tactical *allez-allez* (*i.e.*, oral and moving about) scheme. This is useful if there are a number of candidates for Certificate "A" (All Arms), or for promotion examinations. It also serves to bring in the co-operation of R.E. field units with other arms. It is not essential to carry out this type of scheme within a R.E. unit, as arrangements can be made for officers to attend with the nearest infantry battalion.

(*ii*) A R.E. *allez-allez* scheme. This is the most popular and is probably the most useful, as covering the greatest field of

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instruction in the time available. It is useful for candidates for (*f*) examination for promotion to Captain and for candidates for Certificate "A" (Engineers). Some written work may be introduced. The scheme may embrace either the employment of a whole company or of sections only. In the latter case, the majors can be employed as directing staff and captains must act as section officers. The more senior officers have nearly all had war service, so it is the junior officers who require the bulk of the training and for whom all schemes should be primarily designed. The schemes become more realistic and will arouse more interest and discussion if they deal with the practical handling of sections on the same lines as an exercise with troops, such as can be carried out at camp. This method introduces a warlike atmosphere and serves to counterbalance what may be termed the "drawing office" attitude which some young T.A. officers acquire as a result of S.M.E. projects.

(*iii*) A R.E. project. The Saturday afternoon is spent on the reconnaissance report, Sunday morning on the main report and the afternoon on a conference. This means all Sunday indoors for people who probably spend the rest of the week indoors and so is not so popular. If attempted, officers should be given a very clear line to go on and work in carefully organized syndicates, so that the young officers get instruction from the more experienced. Written work, in any type of scheme, cannot be corrected properly on the spot; this should be done afterwards and the work returned to officers and gone through with them the next drill night (not later, or interest will fade).

The instructions contained in *Training and Manœuvre Regulations*, as regards the preparation and conduct of an exercise without troops, are important. The lessons to be learnt must be very simple, clearly defined and restricted carefully to the time available. All schemes, even projects, should introduce a tactical situation to portray the employment of engineers in conjunction with other arms. This is important in the T.A., as units seldom do any combined training. The scheme should be carefully explained at the commencement of the exercise so that every officer understands the tactical situation and knows exactly what to do.

A combined officers' and senior N.C.O.s' exercise is useful training to indicate the working of company organization. The scheme should embrace the employment of a whole company, be of the *allez-allez* type, every rank (including C.S.M.s, C.Q.M.S.s and mounted serjeants) being given the opportunity of saying what action he would take under the prescribed circumstances. It should be held

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early in the summer season, in April. Held then, it has the advantage of getting all the officers and senior N.C.O.s together, infusing enthusiasm at the beginning of the busy season, and gives an opportunity to discuss the summer's events. All ranks can, in most cases, if necessary, be quartered for the night in their drill hall, but it is a better draw to get elsewhere. If army huts cannot be found, tentage can be arranged. Motor coaches are usually required for transport.

A Command R.E. Officers' Exercise has the advantage that a variety of R.E. units can be brought together, both socially and in the scheme. Officers get the opportunity—rare enough—of meeting those from other R.E. units, discussing difficulties and exchanging views. The scheme must necessarily be on broad lines, so it is considered that it is most useful when designed primarily for the more senior officers. If finance is stringent, these only should attend.

The system thus outlined is based on practical experience and the human factor. It has been found that essential principles in organizing officers' training programmes are: (*i*) the maintenance of interest, (*ii*) not attempting too ambitious a programme (or it will lack support), (*iii*) keeping to essential elementary subjects (or some officers will learn nothing through being out of their depths).

Military Education.

In addition to this organized training, there are other methods of furthering the officer's education. The first is *via* orders. These should be published weekly, throughout the year, on a fixed day of the week, and be posted to officers as a sort of weekly gazette, embracing all the current activities of the unit. The officer's store of knowledge can be kept up-to-date by drawing attention to any A.C.I.s or army orders of interest, to important amendments to manuals and regulations, to any new publications, and to any Territorial articles in the press. In each case, a short summary should be given.

The second is by what the Regular Army calls "talking shop." This phrase does not apply to the Territorial Army any more than discussing golf in a golf club may be termed "talking shop." Discussing military matters in a mess and elsewhere is of definite interest to Territorial officers and educative.

Officers may well supplement their knowledge by reading. The *R.E. Journal* should be taken in by units and circulated. The scale of free issue of training manuals is not very liberal. Extra copies of the *Manuals of Military Engineering* and of *Infantry Training* are necessary; they can be bought regimentally and lent out from the

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unit library. There is a demand for " potted " text-books, but these are disapproved of officially.

Conclusion.

It is realized that any attempt at laying down a system of instruction for Territorials will be criticized, owing to the different geographical considerations of units. What has been written is the outcome of experience with a fairly concentrated unit, but it is considered that the bulk of this may be adapted to the more dispersed type.

The Territorial Army R.E. unit is isolated; it seldom sees any other R.E. unit and so has no standard to go by. Small units without adjutants are even more handicapped. An accumulation of administrative matters presents itself to be dealt with on drill nights and distracts from proper attention to training matters. It is very difficult for the T.A. officers to keep up-to-date and the permanent staff serjeant-major cannot function in the same way as a regular officer can. It is considered most important that small R.E. units should have at any rate the occasional assistance of a regular officer throughout the year, to assist in the preparation and carrying out of training programmes and schemes, more particularly with regard to the officers.

All the instruction which an officer receives will not turn him into an instructor or benefit the unit as a whole, unless he personally instructs men and takes charge of work. This is a simple matter at camp (on which, alone, units are too liable, unfortunately, to be judged); but during the summer drill season and the winter N.C.O.s' courses, it is a good practice to detail officers in advance, in company orders, to give instruction in certain subjects on certain dates. They can then arrive *au fait* with what is required. The officer must have initiative and confidence in command. These qualities can only be acquired by knowledge and experience; they may, however, be assisted by giving every officer a definite responsibility, apart from his company or section duties, in connection with sports, entertainments, bands, institutes or messes. An officer's progress can be sized up annually in his Confidential Report; here is an opportunity for giving him credit for those things which he has done and reference may be made to those things which he has left undone.

The well-being of a T.A. unit depends almost entirely on the tone of the officers and of the initiative they display. The above has been written in the hope that it may serve some practical purpose to those gentlemen who, in spite of these days of " no more war," patriotically give up so much of their valuable time to military matters.

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BILBAO—AND SO HOME.

By CAPTAIN W. G. FRYER, R.E.

ILEX knew nothing of the Careaga Cup until it was brought aboard her at Bilbao, by Señor Careaga himself: scarcely one of her vanquished rivals knows what it is even now. Doubtless they grieve the less on that account. The Careaga Cup is a challenge cup open to yachts of Fastnet Race size, and the race-course lies in the Cantabrian Sea, from Santander to Bilboa. Ocean racers find the distance paltry—it is something under forty miles—but such a race is a delicious change, when it occurs at the finish of the ocean racing season. It gives an excuse for staying in the warm seas a little longer: it is a gentle farewell tussle to offset the fierce battling of the previous three weeks.

During the night watches of the Santander Race—my watch is very garrulous—the scheme for entering *Ilex* in a race from Santander to Bilbao had been examined with care. Our leave was coming to an end, and *Ilex* was without a motor to push her through the calms; but it was clear that we must find time for Bilbao. The Santander Race dinner was to be held on the eve of the coastal regatta. Nothing could be more convenient. Spanish dinners start at 11 p.m., and rival May Week hours when they include a dance as well; so that there would be none of the hasty scrambling, which is usually to be seen on board *Ilex* in the early morning of a race, but just a leisurely change from dinner-jacket to shorts in the bright dawn light, and then all hands working on the racing sails. And that, roughly, is what happened.

The Bilbao Race is sailed under a handicap on form, and does not pretend to be an ocean race. The handicapping is easy, as form is quite visible at that end of the season.

The Santander Race dinner was fixed for September 2nd, the eve of the Bilbao Race. H.M. The Queen of Spain had presented the regatta prizes during the morning, and our enormous cup was safely stowed away in the sail locker before we left *Ilex* for our farewell visit to the shore. The dinner started at 11 p.m. and ended with various welcoming speeches at about 1 a.m. First of all, the President of the Santander Real Yacht Club delivered a masterly quadrilingual greeting to us all. He was then supported by the late General Primo de Rivera himself, who spoke Spanish in an annoyed and querulous manner for about a quarter of an hour with great effect,

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We cheered at the appropriate times. The evening went ahead—a dance, a struggle with a whole queue of taximen, two visits to friendly yachts—and then came dawn. It was time to prepare for the race and we sculled with our solitary oar across the harbour to *Ilex*. "Smokings" were quickly stowed away and the well-salted shorts of ocean racing put on instead. Sail stopping went ahead at great speed; ocean racing trains a crew very quickly. Including the paid hand, there were now only six of us aboard, as Major Armstrong had been lucky enough to find a homeward bound battleship to help him out of his leave troubles. They were D. N. B. Hunt, skipper, Rupert Brown, W. G. Fryer, G. D. McK. Sutherland and M. T. L. Wilkinson. We had arranged to take a local English amateur aboard for the race as interpreter. He was now standing at the Club steps and the dinghy made one last journey to fetch him. "All aboard? Stand by to haul up the dinghy."

Slowly *Ilex* unfolded her white racing wings to the bright early morning of the still harbour. Other butterflies in the harbour, as if encouraged by her, began to try their wings also. Faint voices and the clicking of halliard blocks came from all sides. We had a quick breakfast and weighed anchor with the extra energy it gave us. There was a light air, and we dropped slowly down the anchorage on a gentle ebb tide with little steerage way. *Ilex* came perilously near fouling the 8-metre yachts, which were moored downstream, and they shrank away nervously as we came up to them. Somehow we managed to avoid trouble, and reached the outer anchorage before our rivals.

The start was fixed for 11.15 a.m., across a line about two miles long, between Muros Island and the mainland. The smaller classes were to start first and they now came out in large numbers, towed by every kind of launch. A passing fishing boat gave *Ilex* a short pluck, and we sailed about behind the starting line, watching the metre boats at work. *Hispania V.* (H.M. The King of Spain), and *Osborne* (H.M. The Queen of Spain), were competing in the 8-metre class, and His Majesty gave *Ilex* a *bon voyage* as we crossed tacks. The large yachts—300 tons and over—were gliding about in the background, crowding on sail after sail. There were three of them —*Maria del Carmen Ana*, better known as the ex-*Meteor IV.*, and now Spanish-owned; *Ailée*, owned by Madame Hériot; and *Cetonia*, owned by Lord Stalbridge. It was a hot sunny day with a slight haze on the distant hills: one could not hope for a more charming setting to the large flock of frail white wings, which made up the foreground. A flying boat took off and flew around the men-of-war.

Our wind was dead ahead. We watched the metre classes carefully, and it seemed that those who started on the shore end of the line were the better placed. We discussed race tactics, and Hunt decided to try for a win or nothing. If we sailed the normal course

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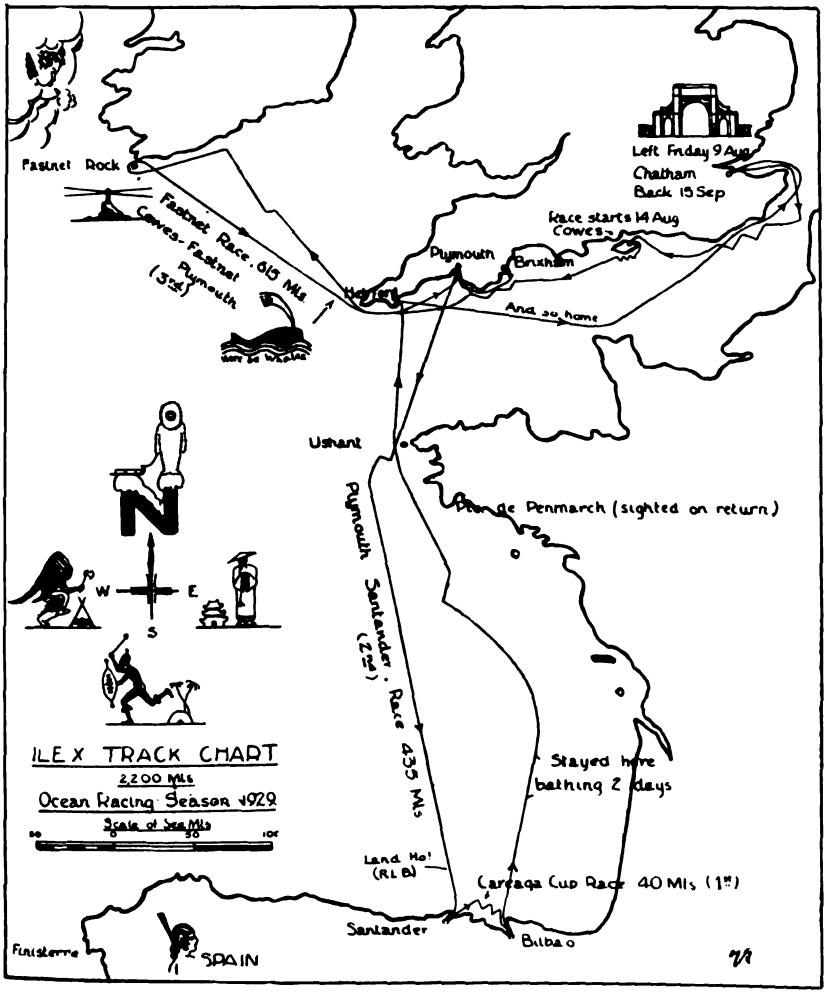
BILBAO—AND SO HOME.



Sketched by C. J. Godfrey, R.E.

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ILEX'S CUPS, 1929 SEASON.

Santander-Bilbao Challenge Cup.

Plymouth-Santander Ocean Race. 2nd prize.

Santander-Bilbao Race. 1st prize.

3rd prize.
Fastnet Ocean Race.

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Bilbao Race Starters

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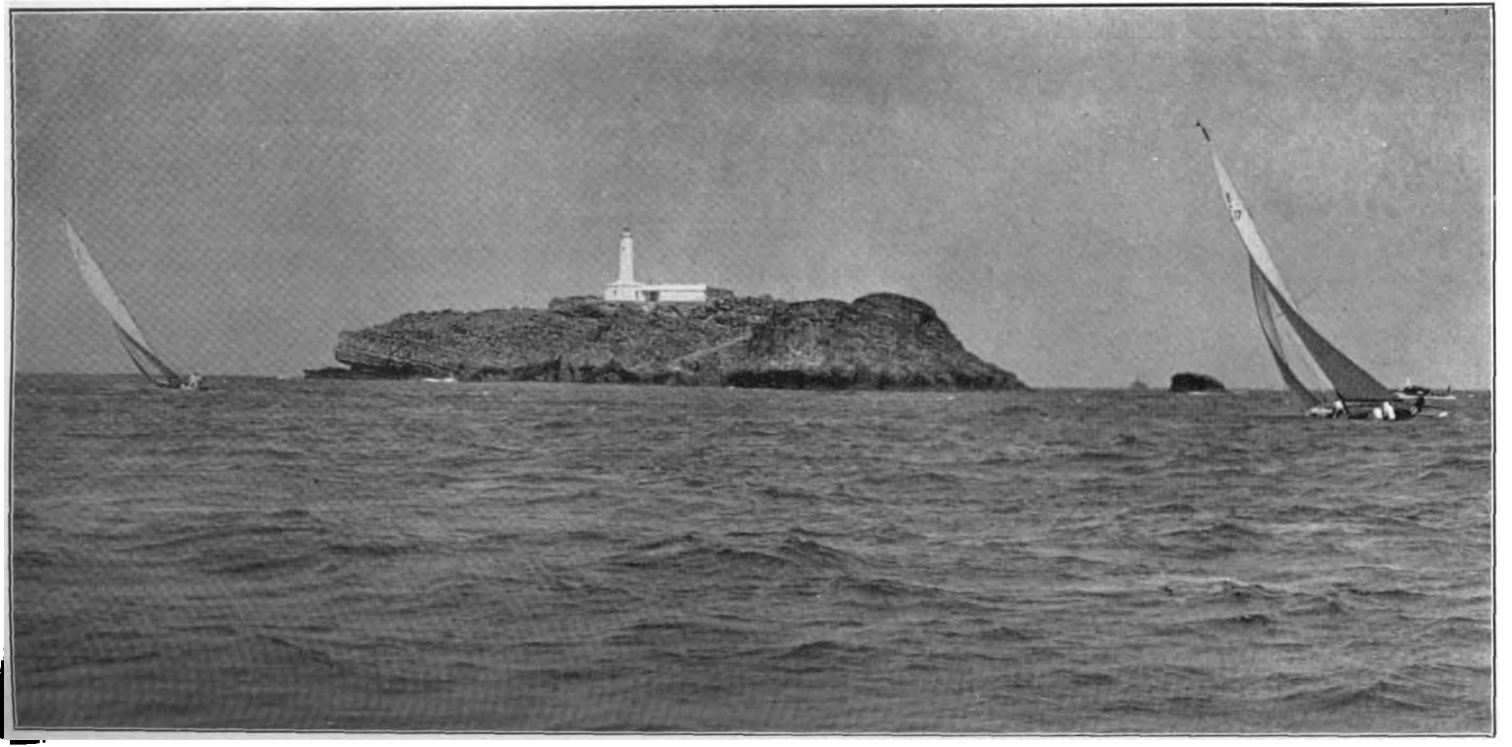

Muros Island. Santander Harbour.

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and kept with our rivals, we had little hope of defeating *Jolie Brise* on handicap, but we had a very good chance of second prize. On the same wind and course, *Jolie Brise* had often shown us that she could slowly pull away from *Ilex* to well beyond handicap range. It was up to us to provide *Ilex* with a better wind and course ; our only hope of doing so lay in avoiding *Jolie Brise* as if she were a plague ship, letting our luck bring us a good slant of wind with the change of water. This we did, and it paid us until quite near the end, when it left us far behind, dismal and dispirited ; then, suddenly, it brought a fine fighting breeze to carry us fast through the gloom to a two minutes' win on handicap, after sailing for nearly ten hours. A grand race.

Hunt made a masterly start. Before the gun, *Ilex* was gambolling innocently with the other ten starters about the centre of the line ; suddenly she shot off to the shore end, let draw all sails, and crossed the line an easy first, with a dashing turn of speed. It was to be a dead beat, and the helmsman had an anxious time making *Ilex* show her best paces in such a light breeze. Sheets were checked every few minutes, and halliards set up afresh on the slightest excuse. Slowly *La Volonté* and *Jolie Brise* crept up on us, and finally *La Volonté* went ahead. But we were not greatly concerned about her, as she was giving everyone time. Then *Jolie Brise* came about towards us on an inshore tack, running through our wake close enough for us to see the fair Spaniards who had come aboard her for the race. *Ilex* kept on the seaward tack, and, in the thickening haze, we soon lost sight of the whole fleet. The wind, luckily, was a little stronger out at sea.

We came about on the inshore tack at 4 p.m. and found that we had lost nothing on *Jolie Brise*, while *La Volonté* was only about half a mile ahead, and seemed to be becalmed. *Guerveur* was inshore, holding fourth place about two miles behind. The wind was still light and at 6 p.m. it faded away badly, leaving all three leaders pitching uncomfortably in some malicious little overfalls off Santoña, which is just over the half-way mark. *Jolie Brise* seemed to be taking them far worse than we were, and her bowsprit went under several times, ducking the man on it when she changed her jib topsail.

Jolie Brise now tacked towards us and we thought that the time had come for us to go out to sea once more ; but she went about close ahead, on sighting *Ailée* carrying a fresh breeze on the offing. We let *Jolie Brise* go out to sea alone after her, determined to stand or fall by our tactical scheme ; so that this time it was our much-feared rival who caught the good sea breeze and ran up quickly into first place. It was too late for us to follow her and we continued tacking along the coast line in a close battle with *La Volonté*. We pulled up level with her, but right on the offing a small fleet of yachts

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was now bowling merrily along behind *Jolie Brise*—all of them nearer Bilbao than *Ilex*.

It was a very gloomy meal that we ate off Santoña. The crew sat below, while the helmsman, alone on deck, tried hard to fill the sails. Suddenly his shout rang out, " My God, the ship's on fire ! " We clattered anxiously up on deck to be met by a hot blast from a furnace. He was evidently right. We looked around for the flames but none could be seen. It grew hotter every moment. Wild looks of apprehension passed among the crew. What *was* wrong with the ship ? And then the wind came. Burning hot gusts swept down on *Ilex* from the land and laid her flat, until we thought that *Ilex* had at last forgotten how to deal with a full-blooded breeze o' wind. On the calm sea she made sudden nervous spurts ahead with the water hissing over the rail. To windward the sky had suddenly changed to a brazen yellow, with dark angry clouds shooting out flaming tongues towards us. It thundered : it would.

As always, Carter knew what it was, and in his informative way said, " Yes, this is the sirrock, that's what this is." He burst into some reminiscences about Cape Matapan. The rest of us had heard much at Santander of that sudden tempest which is known locally as the *borrasca*. The *borrasca* occurs in September in the Cantabrian Sea, and is a ferocious wind which blows for about four hours, with little obvious warning. We had heard nothing of its appalling heat ; nevertheless, we got ready the topsail halliards and stood about, sweating in our oilies, waiting for the *borrasca* to blow a little harder before we reduced sail. *La Volonté*, just inshore, shook up into the wind and ran down her topsails. A 6-metre beside us put about for the small harbour we had just rounded ; whereupon the breeze fadèd away into a light air from nowhere, and we tore off our oilies before apoplexy claimed us. This freakish wind is known as the *turbión* and seems to be incapable of doing anything, except giving one a Turkish bath and shouting a sudden " bo " to startle one.

At nightfall we could make out *Jolie Brise* well ahead with two other yachts close behind her ; it looked as if we could only hope for a fourth, and we sailed on for the finish in a dispirited fashion. It was a black night and odd metre yachts came fluttering across our bows, seeking a faint air. We shifted sails continually, but made little headway. Two yachts behind us gave up and passed us under power ; but we kept on, and suddenly our longed-for wind swept down upon us. We trimmed our sails and went hell's bells for the finish, amid the cheerful shouts of the crew. The lights of the mark-boat were soon abeam, and we opened up our usual pyrotechnic display. Carter burnt dangerous-looking paraffin flares all over the foredeck, while the rest of the crew let off Verey lights and flashed torches. Soon the markboat turned the cold stare of her search-light upon us. We waited. " Bang ! " " There goes our gun.

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Down topsails. Shake her up into the wind." The race was over. It was 10.50 p.m. and we could only guess at the result.

Under reduced sail we bore away for the harbour entrance. An anxious tug came up to us and hovered around with a plaintive message which our interpreter took to be " starboard." We shouted back cheerfully and carried straight on. Later we heard that there is always much nervousness about a rock near the harbour entrance ; but as we had missed our sleep the previous night, and were fairly confident of our chart, we were able to raise but little interest in the poor fellow. He steamed away, feeling rather hurt. Inside the harbour, all was still, and we made our way slowly to an anchorage alongside the huge *Ailée*. *Jolie Brise* was stowing sail as we passed by in the blackness. It seemed quite possible that we had saved our time on her after all. Our crew stumbled below, feeling ready to give the seven sleepers ten in a hundred and beat them hands down. A great peace fell upon the vessel.

We were awakened by a messenger from the Real Sporting Club, Bilbao, who brought invitations to keep us amused for the next week. He knew nothing about the race result. With many sleepy halts, we clambered out of our bunks, to find that bright sunlight had long since roused the rest of the harbour. We bathed, breakfasted, and persuaded Hunt and Wilks to go ashore to get news of the race and revictual the ship. They rowed off across the sparkling water, taking our interpreter with them, while we searched the harbour in vain for a winning flag.

There was much to do on board ; and we had only half-finished stowing the racing sails, when a smart motor-launch crowded with people darted alongside. The owner of *Maria del Carmen*—Señor Pedro Careaga—was in her, and we invited him on board *Ilex* to look around, though none of us felt that our shorts made a very good reception kit. He came with a friend and they carried two silver cups with them. A curious restraint seized us, and, when we took our visitors below, we talked of any subject except prizes and yacht races. The conversation made nervous little dashes at such well-worn topics as the scarcity of leave, the origin of our whisky : we felt that it was up to them to open the important subject. But Carter is a rough, uncouth fellow, quite lacking in such delicate shades of tact. He had been looking on from the fo'c'sle for some time and at last he burst out with, " What's them cups for ? " We were horrified and gave him some jet-black looks. But he had cleared the air, and with much amusement the Spaniards replied, " Didn't we know that *Ilex* had won and that these were her cups ? Really ? Yes. *Ilex* had managed to snatch first prize from *Jolie Brise* by a scant two minutes. . . . " Our shouts seemed likely to lift the deck timbers. A winning flag was flying within 20 seconds, and our visitors left amid cheering shortly afterwards. One of the

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cups was ours for ever; the other was a challenge cup for the same race, which Señor Careaga had just decided to present. It can be won outright by the yacht club which wins the Santander–Bilbao Race twice. *Ilex* is the first winner, so that the R.E.Y.C. has now a very good start on other clubs.

The end of our leave was close upon us, and we had to start for home that same afternoon. Our interpreter did proxy for us at the race dinner, but we had to promise the Spaniards to stay longer next year. Hunt and Wilks rowed alongside about tea-time with tales of the superb hospitality of the Real Sporting Club. Hurriedly we made sail, and turned up to the harbour entrance against a faint breeze, dipping our ensign as we cleared the breakwater at 5 p.m. *Guerveur*, Baron de Neufville's 48-tonner, followed us out on her way to winter quarters at Bayonne. She had sailed in all the races and we watched her closely as she came up under our lee about a mile away. Her crew could just be made out, lining the weather rail; then down came her ensign to the dip, and, like a distant whip-poor-will in the marshes, we heard the faint sound of cheering. We returned their cheers, hauled our ensign close up, and turned, homeward bound, to give a last look at the vanishing coastline.

The crew had shrunk to five, plus Carter, the paid hand, who does not stand a watch. We kept to the remnants of the former watches and divided up into watches of two. Hunt kept skipper and navigator, Wilks and Rupert Brown took one watch, Fryer and Sutherland the other. Night fell and the wind blew fresher from the nor'-west. We handed all but our plain sail and settled down for a rough passage across the Bay. The southern horizon made great play with lightning flashes, and the rolling thunder made us get out our oilskins. We were heeling well over on the port tack, pushing the lee rail right down to the water. Hunt came on deck to help us and we waited for the wind to harden still more. But it must have been another variety of *turbión*, for the wind faded away to rain and light airs long before dawn.

Dawn broke upon a calm sea. We saw *Jolie Brise* about three miles ahead of us, and the sight set the morning watch to work on the topsails. *Ilex* had now run up into the warm and blue waters of the Bay proper. When the forenoon watch came on deck they found it deserted, and the duty watch splashing about in the water some distance away. Everyone bathed, had breakfast, and then bathed again. There was very little wind for the next two days and we spent them grilling in the terrific heat on deck; night or day, it was scarcely worth while changing out of bathing kit. At this point the mate developed a mania for coconut oil, and went about glistening all over with the beastly stuff. It smelt a good deal and he was an unpopular neighbour at meals in the stuffy cabin; besides, he came off on you.

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By the end of the second day he was so dark that he looked to be at least eight annas in the rupee, and was quite satisfied with the result of his hard work.

We tried towing behind *Ilex* in her speedier moments, and thought it great fun, until we realized that we were towing Sutherland under, and that his porpoise jumps were real leaps for breath. At quite slow speeds, a huge bow wave forms in front of one, if the tow rope is fairly long, and then any slight freshening of the wind makes it almost impossible to get back to the ship.

The calm nights were enlivened by lightning displays and busy little wave concerts. These wave concerts would start in a gentle murmur away out to the west, and approach in a crescendo of chatter and lap-lapping. They were too small to move *Ilex*, and after playing around us for a few minutes, they disappeared to the eastward. We scanned them for signs of fish but found none. The tunny line we towed behind did nothing but get rusty and tie itself up with the patent log.

After the second calm day we decided to start single night watches, as there was so little to do on sheets and tiller. Fryer and Sutherland took the early watches and spent their time star-gazing and listening to a couple of whales gambolling round the ship, but during the middle watch, the wind freshened from the east and gave Wilks a strong man's job to do. Somehow he handed the jib-header alone, but, by daylight, *Ilex* was staggering into a steep, breaking sea, and the cry went up for all hands on deck.

We tumbled up to be met by a wet deck and a boisterous wind. The sea was too steep and confused for us to push *Ilex* through it in comfort, and Hunt decided to reef down to double-reefed-main and No. 2 jib. This meant plenty of wet work for everyone, but the sea was so warm that nobody minded getting dipped. The bowsprit-end hand was plunged right in several times, and his only reaction to it was the pleasant thought that he had stolen a march on the others in the matter of the daily bathe. *Ilex* sailed with a far easier motion after reefing, but the irregular waves kept flinging green seas aboard at intervals, in spite of the most careful steering. We were close hauled on the starboard tack all day.

Breakfast was difficult. It was the first rough weather we had met since the Fastnet Race, and the cabin became unpopular in spite of its dryness. Boiled eggs, *in manu* and alfresco, were indicated; by diabolical luck it was Brown, gastronomically our weakest link, who got the bad one. It should not be funny to see a man being hit when he is on the point of going down for the count anyway; but we found it difficult to repress that dry, mirthless cackle, with which, no doubt, an incurable paralytic might view a companion being bitten by a cobra. And so we sailed all morning, going fairly hard, taking in plenty of spindrift and some green seas,

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too. The sun came out and began to dry the ship a little. We cheered up and one of us ventured to the cabin to enquire about lunch.

Quite unexpectedly, it was the best lunch of the year. The morning had been long, wet and strenuous, while breakfast had been very little more than another name for 8 a.m. And now, just as we were getting really hungry, the wind and sea slackened down, while the sun beat down quite cheerfully upon the whole scene. Bully beef, bread and red Spanish wine made a meal which put everyone in gorgeous form. Soon we set the staysail, and as the wind continued to fall away, we shook out the reefs and still kept the decks fairly dry.

That night we saw the faint loom of a light on the French coast —probably Penmarch; later, we also saw a bright masthead light appear on the horizon and shoot swiftly towards us. While Sutherland hunted for the Verey pistol, this turned out to be Venus; so that perhaps our loom wasn't Penmarch after all. Anyway, it gave the watch below a pleasant little thrill. We still met head winds, but *Ilex* kept up a good six knots most of the time.

During the next day and night we saw many other ships and by dawn on the 9th, we were north-west of Ushant. The log states, "Fix by Jove—7 a.m."—the planet, no doubt, being referred to. Our navigation had by now become quite professional and we were getting some very fine results by all methods. The colder green seas of the Channel made the morning watch less amusing, and discouraged the bathers; we were undoubtedly well clear of the Bay.

We averaged under four knots all day on the 9th, but towards nightfall the wind freshened enough to send keen look-outs up the mast in search of land. Carter told us once more his story of how his captain's hair had turned grey in a night, but now quite without his usual zest: there is a feeling of uneasiness about a ship about to sight land which affects everyone. Supper and nightfall came, but still we saw no land. After supper, we relieved Carter at the tiller, and as he walked forward, he spotted the Lizard light over a wave top. It was a grand landfall; so good that we continued on the same course and eventually picked up the Manacles Buoy about 2 a.m. The whole coastline then appeared, and Hunt put *Ilex* about, to make Helford River. We beat slowly up there and anchored just after dawn among the other yachts. We were then five and a half days out from Bilbao, but had grown so used to the sea that we all felt great regret that the sail was over.

Three of the crew left that day after our final dinner. Hunt's father nobly came aboard that night to help us sail *Ilex* round to Chatham, and by 10.30 p.m. we were casting off our tow at Helford River mouth. The sea was fairly calm for much of the way back and we were able to make *Ilex* steer herself for nearly a quarter of the journey. The crew were by now so keen on deep water sailing

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that *Ilex* soon lost sight of the coast, and wandered across to within sight of Alderney. Slowly we came round to the Thames, scarcely meeting one favourable wind the whole way; and it was not until five days after leaving Helford that we picked up our moorings at Gillingham. In the calm watches we put in great work with the sextant and Aquino. Previously the navigator's mate had done some very rough work with them. In the Fastnet Race, he had fixed *Ilex* in the Bristol Channel, when Falmouth was clearly to be seen to the northward. Off Folkestone on the way back, he took a sight on the moon, which gave our position to within a mile. All were suitably impressed.

Most of the passage home from Helford was a dead beat. This would have been very tiring with such a small crew had we not tried some single-handed sailing tricks. The most obvious one was to enrol St. Christopher as a helmsman. We balanced the sails carefully and rigged up a simple tiller lock which worked so well that the crew scarcely touched the helm for two days, and yet *Ilex* made some excellent legs to windward during that time. We trusted St. Christopher so much that one of us spent his watch reading below with brief hourly visits to look out for steamers. It was quite calm enough to allow one to hear ocean traffic from the cabin.

Anyone who has sailed much on *Ilex* must have heard several of Carter's salt sea yarns; on this passage home he excelled himself —keel-hauling admirals, captains who always saw a flogging before breakfast, the admiral who was eaten as salt pork—we heard all the old favourites and many new ones. An awful eagerness to see home made him produce them to while away the time. He was the only one who failed to trust the St. Christopher, and when he came on watch his fingers soon strayed to the tiller and upset the accurate setting in case the wind had changed recently without affecting the burgee: never had we seen him so eager to get every knot out of her. Always slow, but never quite stopping night or day, we rounded the Forelands and sailed up the Medway with a light air and the evening flood tide.

Theresa was just stowing sails when we moored in the darkness, and her crew came aboard to view the cups and share our punch. It was nearly midnight when the last dinghy load left *Ilex* to rest in peace at the end of her 2,200-mile cruise. We shot off a Verey light to mark the event, and stepped ashore in time to hear the local picquet telling the police that he didn't think it could be a fire call after all. We left them wondering, and strolled up to the Barracks, glad to stretch our legs after a month of ocean sailing.

[NOTE.—The Editor desires to acknowledge with thanks the courtesy of *The Yachtsman* in lending blocks for this and previous articles.]

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THE INTERPRETATION OF AIR PHOTOGRAPHS.

By CAPT. A. C. DUFF, M.C., R.E.

IN the *Army Quarterly* of January, 1930, there appeared an article entitled " Air Photographs and Their Military Uses," and in it an attempt was made to describe the various uses to which the Army can put the photographs taken for it by the R.A.F. One of these uses is to provide information of enemy locations, enemy movements, and enemy activity generally, for the benefit of the General Staff, and this information is extracted from the photographs by the process known as interpretation.

So little is known about interpretation under conditions of mobile warfare, and the impressions of it that survive from the Great War are in some ways so misleading, that it seems desirable to record in print such data as there are available, and to describe the many uncertain factors which make it difficult to predict what value we may expect from interpretation in the opening stages of warfare against a civilized enemy. The material on which there is to work is so limited in quantity that views can only tentatively be put forward, and such views as are herein expressed are those of the author alone.

Interpretation may be defined as the art of recognizing on a photograph the marks of military activity on the ground. It is desirable to restrict the term to its proper use, and not to apply it to the recognition of ordinary topographical detail; nobody would speak of interpreting a map, and it is equally unnecessary to talk of interpreting on a photograph the natural features of the ground.

There is no need to stress the value of interpretation. It is possible to photograph any part of the area occupied by the enemy; his Base and L.-of-C., his forward defences, his battery positions, his aerodromes and hospitals. If the detail on the photographs is correctly interpreted, the Intelligence Section of the Staff is presented with a mass of information of the greatest value. It may be advanced that the same information can equally well be obtained by the pilot, but this is not so. The pilot endeavouring to reconnoitre country below him labours under many handicaps. His field of vision is limited by the spread of the lower main planes; his attention is distracted by having to fly the machine, and, very possibly, to dodge the fire of " Archies "; his powers of observation may be impaired by discomfort or fatigue, and, finally, his vision is restricted to what he can see with the naked eye.

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None of these limitations applies to the camera. The camera is fixed in the bottom of the fuselage, and has a clear field of view; it is insensitive to discomfort, fatigue, or other personal factors; and by an alteration of the lens it may be endowed with any degree of telescopic sight considered desirable. There are two particulars only in which the camera is inferior to the pilot. Its first disadvantage lies in the fact that it is blind to movement, for its period of observation is a minute fraction of a second, while movement quickly attracts the pilot's attention. The second drawback lies in the time factor; before the information obtained by the camera can be made available the machine must return to its aerodrome and land, and the photographs must be developed and printed, a process far slower than the pilot's report of what he sees, sent down at once by R/T. These are the factors that have to be borne in mind when deciding whether any particular reconnaissance will be better carried out by the pilot or by the camera, or by a combination of the two.

To return to the question of interpretation, a photograph of an area in enemy occupation will convey little to a man who is unused to looking at photographs of this kind. Unless the photograph is at an exceptionally large scale it will not show men, horses, wagons, or guns. Columns of troops or transport on the road may appear, but once units are deployed, or scattered among billets, they become invisible, and the only indications of their presence are the marks they make on the ground. The study of these marks is the art of interpretation.

These marks fall into two categories. First are the marks made by digging. As soon as a hole of any kind is dug the texture of the ground is altered; the excavated earth lying round the hole is smoother in texture than the grass or scrub surrounding it, and consequently reflects more light upwards, and shows lighter; while in the hole itself one side is in high light, and shows light, while the other side is in shadow, and shows dark. Even a hole only two or three yards in diameter shows up clearly on a small-scale photograph.

The second series of marks are those made by occupation. A party of men walks across a field. The grass is crushed down under their feet, and again the texture is altered, for the flattened blades of grass reflect more light upwards than the blades standing erect, and consequently appear lighter. If movement continues along that route a track is formed, and when the grass is trodden right out the bare earth appears lighter still.

A track of this kind is of no particular interest, but may be of value by indicating the point to which it leads; and in addition the making of tracks is often incidental to some other occupation. If, for instance, barbed wire is erected at night, in the morning there will appear tracks along the edges of the entanglement, though the entanglement itself may be quite indiscernible. Or again, a trench

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or a battery position may be covered over with sods of turf so carefully that it is effectively concealed, but it may yet be easy to pick up the patches from which the turf has been cut and the tracks along which it was carried to its destination.

It is on the correct reading of such marks that interpretation is based, and a moment's reflection will show that it is under conditions of position warfare that interpretation will give the fullest and most accurate results. During the War, certain areas were occupied for weeks, months, even years on end, and throughout the period digging went on continually. The German lines were photographed at frequent intervals, and a comparison of each series of photographs with the series last obtained showed clearly the activities which had taken place in the interval. His tactical methods and his standard designs in field defences were known, and it was soon realized, to take an illustration, that a certain peculiar zig-zag marking indicated the emplacements of a field battery. Other characteristic markings were similarly noted; an air-line was indicated by a fine, straight, white line, with small dots spaced at even distances along it; a buried cable showed as a faint line with a peculiar blurred edge; a light railway was distinguished by the smoothness of its curves. Thus was gradually built up a kind of dictionary, in which one could discover what characteristic markings any particular form of enemy activity was likely to produce on the photographs.

The information thus acquired was of immense value in arriving at an appreciation of the enemy's plan. If on a certain sector of the front the roads and railways were seen to be pushing forward towards his front line; the number of hangars on his aerodromes to be doubled; his battery positions to be largely increasing in number; the traffic round his ammunition dumps to be heavier; and his signal system to be extended and duplicated; then it could be assumed that an attack on that sector was in preparation. The photographs, it is true, gave little evidence of the probable date of the attack, but they indicated with accuracy the frontage over which the attack would extend.

The results obtained during the War tended to give rise to an impression that it was possible to obtain from air photographs very complete indications of an enemy's plans and intentions. Emphasis must, however, be laid on the fact that the quantity of information then obtained was largely due to the extremely favourable conditions —those of position warfare—that then prevailed, and that in the opening stages of a future European war such results could not be expected. The war for which the Army is training is not the position warfare that may prove unavoidable, but the mobile warfare with which a campaign is bound to open; and it is under mobile warfare conditions that we want to know what interpretation has to offer us.

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The answer to this problem is highly obscure, but certain tentative views have been reached and may serve at least as a guide. They are based principally on two exercises carried out in 1929 under widely different conditions; one in the United Kingdom, the other in Egypt.

In the former exercise a battalion position was occupied and defences constructed during a period corresponding to five days under war conditions. The troops who carried out the work were at the same time practising the use of natural cover and the construction of camouflage. The ground was hilly and broken, covered with gorse, broom, and heath, with occasional clumps of trees, and as it had been dug over on a previous occasion it was scarred with the lines of filled-in trenches. The work done included a number of section posts, two concrete machine-gun emplacements, two anti-tank gun emplacements, and some short lengths of barbed wire apron fence. The area was photographed before work began, and again at intervals during its progress.

The amount of information that could be obtained by the most careful examination of the photographs was meagre. It proved only to be possible to mark down a certain number of points where digging had taken place. It was not possible to distinguish one kind of digging from another; section posts from machine-gun emplacements, or machine-gun emplacements from dugouts. No trace whatever was visible of the apron fences, for in that tough undergrowth tracks were very slow to form.

It must also be noted that the information obtained, such as it was, was obtained by the aid of a minute comparison of the photographs with the earlier photographs taken before the position was occupied. Had these earlier photographs not been available the value of the interpretation would have been still further decreased.

From the point of view of interpretation the conditions were about as bad as they could be. The topography was entirely unfavourable, and the enemy was making skilled use of natural cover and of simple forms of camouflage.

Under such conditions the value of interpretation may be assessed as follows. It will be possible to ascertain the approximate extent and depth of the enemy position. It will not be possible to locate more than a proportion of his defensive works, or to distinguish their nature, or to detect barbed wire entanglements.

The exercise in Egypt was on a larger scale. A small mixed force took up a defensive position in the evening and entrenched it during the night. The position was photographed on the following morning.

The topography was of course entirely different from that of the former exercise. The desert, though broken and hilly, offered no natural cover of any kind. Although the time of occupation was so much shorter—a matter of hours instead of days—it was possible to

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pick out on the photographs practically every point at which digging had taken place. Some simple camouflage had been attempted with varying success, but it was naturally only possible to apply camouflage to a small proportion of the digging zone. It is worth noticing that in such country a series of photographs taken before the position was occupied was not found necessary for the practice of interpretation.

The results that can be expected *under such conditions as obtained in Egypt* may be thus summarized. It should be possible to determine the extent and depth of the enemy position, and the areas in which his resistance is likely to be concentrated; to locate a high proportion of his machine-guns and artillery; and perhaps to make out his organization, *i.e.*, how many main units are present, and how they are disposed upon the ground.

Under two given sets of mobile warfare conditions these are the results that interpretation can give. In trying to decide what results we may expect under other conditions, the following are the factors that must be considered :—

1. *The local topography.* The success or otherwise of interpretation depends mainly upon the type of country occupied by the enemy. The more broken the country, the more difficult interpretation becomes. Thorn, scrub, gorse, broom, heather, are all tough, deeply rooted, and hard to destroy or even crush down. Country of this kind, moreover, appears on a photograph as an intricate patchwork of constantly varying tone, ranging from very dark to very light, thereby making it peculiarly difficult to distinguish those changes of tone, due to military occupation, upon which the successful practice of interpretation depends.

   At the opposite end of the scale is open arable country or pasture land. The bare plough, the stubble or short grass, or the grown corn, all provide a medium on which changes of texture are immediately apparent. A flat desert would offer equally favourable conditions; more so than the Egyptian desert round Mena, which is far from flat and consequently contains many small shadows to distract the eye.

   This factor of the relation of topography to interpretation is one which a commander might profitably consider when taking up a defensive position which has to be held for a period of more than a few hours. If he is able to choose broken ground, such as that described, he is thereby offered a degree of immunity from air reconnaissance that in open country no amount of labour expended upon camouflage would afford him.

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2. *The period of occupation.* Generally speaking, the longer a position is occupied the more easy does interpretation become.

A grass field over which troops have deployed will show only small and impermanent traces of their passing; but if they continue to occupy the position the tracks of reliefs, ration parties, patrols, etc., soon become conspicuous, while any digging that they do is at once apparent.

The only exception to this rule is when the period of occupation is so protracted that elaborate measures of camouflage are brought into practice. To take an illustration: when a battery of artillery goes into action it will not, if photographed during the first few hours, appear very conspicuous. As time passes the construction of gun-pits, the movements of ammunition-wagons, the blasts of the discharges, the coming and going of personnel, make markings which become more and more distinct. If, subsequently, effective camouflage is erected and track discipline enforced, the signs of the battery will gradually fade out until they become almost or quite invisible. Such measures of camouflage, however, are hardly practicable under conditions of mobile warfare, both on account of the time required for their execution and the quantity of material necessary.

Under mobile warfare conditions, the possibilities of camouflage are largely limited to what units can do for themselves without assistance from technical troops. They can do a great deal. The intelligent use of natural cover, the screening of newly-turned earth with brushwood or turf, the covering of important points with wire-netting or canvas or any other available material, all help to puzzle and mislead the enemy in his attempts to read the photographs.

3. *The skill of the interpreter.* The best possible results from interpretation clearly cannot be expected unless the man who carries out this duty has certain qualifications. The two qualifications he requires are tactical knowledge and practice.

It is essential that the interpreter shall have a sound and thorough knowledge of the enemy's organization, tactics, and system of administration. Before he begins to examine the photographs he must be able to form a picture of what the enemy's " lay-out " is likely to be. Does the enemy always cover his front with anti-tank obstacles, natural or artificial? Does he dispose his automatic weapons in fours, in pairs, or singly? Does he push up artillery close behind his forward units, or does he hold it well back?

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Is his ammunition supply still entirely on wheels, or has he begun to have recourse to dumping? When his batteries occupy a position what kind of emplacements do they build? To these and a score of similar questions the interpreter should know the probable answer before he begins his work.

On the outbreak of war the answers to some of these questions must be problematical, but as the campaign proceeds, and data become available, the Intelligence Section of the General Staff should be able to provide the answers with some degree of certainty.

Given this knowledge, the remainder is a matter of practice; and probably less practice is required than is generally supposed. After a few days an intelligent man should be able to extract most of the information that is to be had.

4. *The photographic factors.* If interpretation is to give good results the R.A.F. must first produce good photographs at a suitable scale.

A "good" photograph for interpretation purposes must be clear and sharp, and should show a well-defined shadow effect. Assuming the efficiency of the technical equipment and the competence of those who have to use it, the other requisite is fine weather. It does not follow that a day which is suitable for photography on the ground is suitable for photography from the air, and in the United Kingdom only one day in three, taken on an average throughout the year, will permit the production of "good" photographs. Thus it is impossible, except in a peculiarly favourable climate, to reckon on photographs for interpretation being obtainable when they are wanted.

The question of scale presents many complications. A photograph intended for the examination of *ground* is better taken at a comparatively small scale; say something round 1/10,000 or smaller. At such a scale each print covers a fairly large area, and yet the features which one wants to see—houses, roads, hedges, trees, etc.,—are sufficiently visible. A photograph intended for *interpretation*, however, cannot show too much detail, and the scale consequently cannot be too large. In country that is at all difficult a scale should be aimed at of not less than 1/5,000.

The R.A.F. will usually have little difficulty in producing the approximate scale required. The scale of a photographic print is dependent on three things. First, on the altitude of the machine; the higher it is flying, the smaller the scale. Second, on the focal length of the lens employed; a long focus lens gives a large scale, a short focus a small

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scale. Third, on the degree of enlargement introduced in printing from the negative; this is subject to limitation, for with any given negative there is a degree of enlargement above which the amount of detail shown is not increased. When photographs are to be taken the flying height of the machine is first settled, depending on the height of the clouds below which it must fly, and on the enemy A.A. defence, which may force it to fly high. The scale required is then produced by adjusting the focal length of the lens and the degree of enlargement.

Unfortunately there still remains the factor of time. To take a concrete case, Corps H.Q. requires for interpretation purposes photographs of a certain area. It is worked out that if the photography is done at a scale of 1/10,000 it will require 25 prints to cover the ground.

Now 1/10,000 is too small a scale to be satisfactory for interpretation, and Corps H.Q. may well ask for a scale of 1/5,000. This means, however, that to cover the same area will require not 25 x 2 = 50 prints, but 25 x 4 = 100 prints. And should they ask for a scale of 1/2,500 it means 25 x 16 = 400 prints.

These numbers are unmanageable. While a demand for 25 photographs may take a Squadron, R.A.F, given good weather and barring accidents, about three hours to complete, a demand for 400 photographs may take them fifteen hours or more. (These figures are dependent on many fluctuating factors, but would represent a satisfactory achievement.)

Nor is this all. When the 400 prints have been prepared and delivered by the R.A.F. they have yet to be examined, and the detailed examination of 400 prints would occupy a matter of days.

The answer to the problem appears to be that when time is precious as in mobile warfare it always is, the interpreter must be content with photographs at a comparatively small scale of the area, extending presumably across the Corps front, with which he has to deal; and though he may and should demand in addition photographs at large scale of certain points of particular interest or importance, he must keep those demands within strict limits. If he does not, but asks for photographs of large areas and at a large scale, congestion and delay are bound to result.

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EARTHWORKS.

By MAJOR W. L. WOOD, O.B.E.

DURING the War the following points were impressed upon the writer of this note in his experience with Field Companies R.E. and later with Railway Troops R.E. :—

A. The great importance of rapid digging to secure protection and the inability to dig of (*i*) the average infantryman and (*ii*) the average sapper in the new armies at least.

B. The difficulty of getting a supply of tools up to the forward position during an advance.

C. The unsuitability of the tools provided (*i*) as regards type and (*ii*) as regards condition.

Taking these points in order :—

A. In open warfare, or during movements of advance or retreat in close warfare, the necessity for troops being able to protect themselves by rapidly digging themselves in is obvious, and presumably is not less so to-day than in the late war.

A soldier who has dug himself in quickly and well is better able to resist a counter-attack, quite apart from being protected from the shelling and M.G. fire, which is always directed against newly-gained positions.

In trench warfare the need for good digging is no less important; during the War, whole brigades were sent up night after night to make communication, drainage or jumping-off trenches, and incurred heavy casualties in doing work which could have been performed by 20 per cent. of the strength, had they known how to dig and been animated by the desire to get their task done and not merely by the desire to get back to hutments. Here a distinction must be made between the outlook of a man digging himself in, and that of a man making a trench which, as far as he knows, he will never be called upon to occupy, but which is turning his "rest" period into a very bad joke.

Many men, of course, knew how to handle a spade, but their work naturally slowed down to the pace of their inexpert comrades, while work at night in strange surroundings, in soil full of roots and other obstructions, reduced all to a common level of incompetence, which only hard training with tools properly conditioned could raise to efficiency.

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It must be borne in mind that nearly all the work in the forward area *did* take place at night; it was the writer's experience that working parties were sent up with insufficient officers and N.C.O.s, that those in charge knew nothing and cared less about the work, but were concerned to get their men back safe and sound to their rest with as little delay as possible, and the net result of their labours was only some haphazard turning over of the top soil, which by the following night had made the site a quagmire.

The sappers, who by precept and example should have been the backbone of the work, had not the experience necessary; plumbers, carpenters or bricklayers in civil life, they were all that could be desired when laying pipes or making duckboards, but few of them ever became "sappers."

In this black picture there were bright, though exceptional, patches, and the foregoing observations are of an entirely general character and are certainly not directed against the 9th Division, in which the writer had the honour to serve for a portion of his time in France: for obvious reasons, it was difficult and invidious to formulate complaints against individual units for which, in other respects, one entertained the highest admiration and respect.

It is submitted that the lesson remains; there is need for far more training under practical conditions in digging, and in inculcating in the infantryman an appreciation and care for his spade akin to that which he has for his rifle—"a very present help in trouble."

B. The difficulty of getting a supply of tools up to the forward positions during an advance.

During the month of July, 1916, on the Somme, there were drawn from R.E. Stores for issue to the 9th Division (*inter alia*) so many thousands of picks and "shovels," that an acute shortage existed at the "dumps," although these thousands were strewn on the battlefield, just short of where they were required, to be destroyed, burned, buried or salvaged at a later date.

Only a small proportion of these tools ever reached the front line; the already heavily-burdened soldier let his pick or spade go first of all—quite properly, no doubt, if something had to be jettisoned. Each brigade or battalion going up looked for, and got, a complete equipment—"Q" could hardly tell them to pick them up on the battlefield, although that was really the solution of the problem, for, as it was, they were dropped on deployment after being carried two or three arduous miles.

The result was, for the time being, a grave shortage of tools right back to Base dumps, a waste of transport and most precious road space, and still no tools in the front line.

The writer has no suggestions.

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C. The type and condition of the tools supplied.

(*i*) *Type.*—The writer with diffidence suggests the use of the half-round narrow spade, which is in general use for earthworks in railway work abroad.

It does not lift too big a load, it holds its load until thrown, it is a powerful cutter in roots and it is rather more handy to carry; in very soft ground, as in very hard, it is not inferior to the open spade.

It is true that the half-round spade cannot be used as a shovel for moving gravel and ballast, and that "pretty pretty" gardening effects on glacis and parapet (to charm the inspecting eye on Great Days!) cannot so readily be attained, but, on the other hand, it digs a post-hole to perfection.

(*ii*) *Condition.*—It did not seem to be recognized that the condition of a spade to a digger is just as important as that of a chisel to a carpenter or of a rifle to a rifleman. Spades were invariably issued to working parties either as they came from the makers, *i.e.*, quite blunt, or, if "second-hand," rusty or caked with mud as well as blunt.

The writer of this note has had considerable experience with earthwork gangs working on piecework in making railway embankments; these men are able to dig over 20 cubic yards per man per day from a borrow pit and to wheel and tip them to form a low embankment; their spade is their proud care; it is kept knife sharp and silver bright; work with it by comparison becomes a pleasure; each man has a file in his belt with which he maintains the edge.

In France, it was pitiful to see hundreds of men trying to dig with tools with an edge $\frac{1}{8}$" thick, with the blades rusty and caked and made heavy with a pound or two of Flanders mud.

No spade should be issued from store that is not sharp and bright and oiled; to prevent accidents in carrying a guard might be required on the cutting edge; every man should be taught that he can save himself endless toil, and possibly his life, by so maintaining his spade, and that it is as absurd to work with a dirty, blunt spade as for a bank clerk to write his accounts with a walking-stick dipped in ink.

This fault was noticeable in all except perhaps the specialist units such as Tunnellers', Drainage Companies, etc., and the writer ventures to lay stress on it because it was not generally realized; the opinion held was that a spade was a spade and there was nothing more to be said or done.

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SOME SIDELIGHTS ON IRAQ'S PROBLEMS.

By "MARCO DOUGLAS."

Note.—The historical statements contained in this article have been obtained mainly from the principal actors in the various scenes.

IRAQ is a subject on which in the past we have heard a great deal, and of which in the future we shall probably hear a great deal more. It is, however, difficult to get a true perspective of Iraq and its problems unless we are clear as to its origin.

The dust of the four years of fighting hung deeply over Europe after the War, and even now the sequence of events in Europe is not too clear in the mind, and the happenings in the East, save in the case of the actual spectators and actors, seem too hazy and complicated to be understood or remembered. It seemed as if, out of a welter of diplomatic intrigue, peace conferences, correspondence, and even rebellion, there emerged the Cairo Conference in 1921, and shortly afterwards the Iraq State was formed.

The country itself is bounded on the north by Turkey, on the east by Persia, to the south and south-east by Nejd, and to the north-west by French Syria. The northern and eastern boundaries are mountainous, the country resembling the Indian Frontier, but inhabited by Kurds who, although good fighters, have nothing like the military skill of the trans-border Afridi and Pathan.

The remainder of the country is flat. From the foothills to the western side of the Euphrates it is fertile, and, where there is water, cultivated. Beyond the Euphrates there is the so-called desert. This is not a desert as the French understand the term in the Sahara. There an officer's patrol is over country three to four hundred miles between water points. In the Iraq desert, in winter, in no place can one get further than twenty miles from water, or in summer more than forty miles. Possibly this does not sound a very great distance, but when it is realized that the maps are very inadequate, and that the desert water points are wells which have no vegetation at their mouths, it is easy to see that if one misses a well, one may have to go a very long way before finding another. So much for the geography.

For some four hundred years before 1914, the Arabs of Arabia had been under Turkish rule. There had always been a feeling of hope

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that some day independence would be realized, and this feeling gradually became more intense and there started a movement which became really active in 1876. If 1848 can be described as "the turning point in European history at which Europe failed to turn," then 1876 may be described as the turning point in Turkish history, at which Turkey turned from looking west to looking east.

In the Turkish Empire this was a year of revolt. Bulgaria, Rumania and Serbia were all born from movements begun at this time, and, in this same year, the Arabs began to take active steps to establish, eventually, their independence. Committees were formed throughout the Turkish Army and propaganda was spread among the Arab peoples. The movement began to gain force, and soon found that alongside it another similar movement in the Turkish Empire was being prepared. This was the "Young Turk" Movement. Many members of the Arab Movement were also members of the Young Turk Movement, and eventually the two movements united on the understanding that the Young Turks, should they gain power, would grant the Arabs independence under the Turkish Suzerainty.

In 1908 the Young Turks came into power, and immediately repudiated their agreement with the Arab Nationalists. The Arab Nationalist movement, however, had gained too much momentum to be suppressed, and committees sprang up again in the Army; and was directed from a central committee in Constantinople. Steps were taken by the central committee to get in touch with the British authorities in Egypt, and Lord Kitchener was approached. Though he made no promises, he smiled rather than frowned on a movement which he foresaw would be of inestimable value in the event of war with Turkey.

The movement was gaining impetus rapidly, and in 1913 an Arab Parliament met in Paris. The delegates were from all the Arab peoples subject to the Turks, with a few others from North Africa. This Parliament achieved little except contact between the various members, but it was a gesture and an important one. The Turkish government awoke to the seriousness of the Arab preparations, and early in 1914 arrested as many of the central committee as they could. Several escaped, among whom was a young officer who had been on the staff of one of the Turkish armies near Constantinople.

He fled rapidly, and eventually, after adventures that rival any work of fiction, arrived in Basrah about the beginning of August, 1914—in time to hear of the outbreak of war. No time was lost. He got in touch with Sayied Tayid, the most powerful Arab locally, and a man of whom the Turks stood in awe, and persuaded him to take a message to the British Consul. He said: "Tell the British Government that this war which has just broken out between Germany and Britain is going to include Turkey on the side of the

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Germans, and that, if the British Government are prepared to promise the Arabs independence on the conclusion of the war, the Arab Nationalist Party will guarantee that the two Army Corps now in Iraq will come over to the Allies."

He waited; and waited; and waited; and nothing happened. By this time the Turkish authorities had again got on his track, and he fled down the Persian Gulf to Bahrein. There he stayed until he heard news that British forces were assembling in Bombay to occupy Basrah. He again went up the Gulf, this time to Fao, and got into touch with the British Consul at Mohammerah, and sent once again the same message. Again there was no reply.

When the British Troops occupied Basrah, he got into touch with the Chief British Political Officer with the Expeditionary Force, and made the same offer, this time excepting the Northern Army Corps, which had been relieved by a non-Arab Corps from the interior of Turkey. "After all," he said, "it will cost the British Government nothing to make the promise and to allow me to try, and it may be that, instead of having to fight your way to Baghdad, you will be able to send up occupying parties, and in a matter of days the Allies will be provided with a spectacular success; if I fail, you will have lost nothing." Once again there was no reply, and he decided that, since the political policy of the Expeditionary Force was not dealt with by London, no good could come of his remaining in Iraq, and he applied and was sent as a prisoner of war to India.

In March, 1915, the Gallipoli campaign started, and among others who distinguished themselves on the Turkish side was an officer who had, a year before, been the Adjutant at the Turkish Infantry Depot at Aleppo—Jaffar al Askeri—and he was awarded the Iron Cross.

Pre-war German preparations had been thorough and had included propaganda and preparation for revolution among the Senussi in North Africa. In order to contain as great forces in Egypt as possible, the Turkish General Staff decided to use these preparations and to assist the Senussi to revolt. Jaffar was sent across the Mediterranean in a fishing boat under the noses of the British Fleet, and discovered that, before any effective revolt could take place, the Senussi had to have money, arms and ammunition. He therefore returned once again in his fishing boat, and made arrangements for money and the supply of the necessary arms and ammunition, this time returning in a submarine to North Africa. Directed by Jaffar, the Senussi broke into revolt, and after a hard campaign they were finally defeated by a British Force consisting largely of armoured cars and cavalry. Jaffar was wounded and captured by the Dorset Yeomanry, taken to Cairo and put in hospital in the Citadel. After some time he decided to attempt to escape. One night he tied his sheets together and lowered himself out of the window. Unfortunately, Jaffar weighed eighteen stone, and the sheets were ordinary

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army quality. As a result, they broke, and Jaffar fell to the ground and broke his leg. He was collected in the morning and taken back to hospital, where, in due course, he recovered.

At the beginning of 1916, the Arab Bureau in Cairo had been investigating the possibility of bringing King Hussein of Mecca into the war on the side of the Allies, and thus threatening the Turkish left flank, which rested on the desert. As his army—such as it was in those days—was very inefficient, it was decided to strengthen it by means of Turkish-trained Arab officers, many of whom had fallen into the hands of the Allies. One of the first to be sent to the Hedjaz was Jaffar, and shortly afterwards Nuri Saiyed followed him from Bombay. The Arab revolt had started. The Palestine campaign continued and, as a result of some very excellent work in the company of Colonel Lawrence, Jaffar was awarded the Cross of St. Michael and St. George. Lord Allenby, who decorated him, arranged a Guard of Honour for the ceremony consisting of the Dorset Yeomanry, who were at that time serving in Palestine. And thus, in one campaign this remarkable soldier, Jaffar al Askeri, won, and won honourably, both the Iron Cross and the Cross of St. Michael and St. George—a unique record.

The Palestine campaign eventually ended, and the Arabs, under the leadership of the Emir Feisal, King Hussein's third son, found themselves in Damascus. There a temporary state was organized, and everybody settled down to await the final decision of the peace conference sitting in Paris.

Time passed, and it seemed that the promises which had been made in the war would never be fulfilled. So, when in 1920 the tribes on the Euphrates who had not seen the might of the British Armies during the War, broke into revolt, the Syrian Government rather countenanced than suppressed what seemed to be merely another movement towards independence. The rebellion was at last put down, and the British authorities then had to face the question of what was going to happen to Iraq, and what was going to be done to redeem their promises to the Arabs.

A conference was called in Cairo in 1921, presided over by Mr. Winston Churchill, and there, very largely owing to the clear and long-sighted views of Miss Gertrude Bell and the courage of Mr. Churchill, it was decided to create an Iraq State under British Mandate, thereby relieving the British taxpayer and at the same time giving the Arabs such independence as British international commitments would allow. The control established by the Mandate was naturally very irksome to the Arabs, but they were, on the whole, pleased to obtain even this measure of independence, the more so as the measure held out the promise of complete independence in the future. From the British side the arrangement was a good one: prestige and war-time promises were re-established, and the British

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taxpayer was relieved of the very heavy burden of the defence of Iraq, with no likelihood of those Iraquis who had befriended Britain being returned to the tender mercies of Turkish misrule.

In order to achieve a measure of security for the new State, Jaffar, who attended the Conference, agreed to become First Minister of Defence and to form the army. To help him he had two or three hundred ex-Turkish officers of varying degrees of intelligence and education and about half a dozen British officers, with some of whom he had previously served in Palestine and Syria. And thus he started on a task from which a man without unbounded enthusiasm and energy might reasonably have shrunk. The British forces in Iraq could not be expected to forget, and did not know, as a rule, enough to forgive, the revolt of the previous year, and the Ministry of Defence was met at the outset by a certain amount of understandable suspicion. In most armies the hundred-and-one regulations—clothing regulations, army regulations, field service regulations, army forms, methods of accounting, budgets, handbooks for weapons, law, etc., exist as a result of many years' slow and careful work. The Iraq Army started with none of these things, and from the outset it had to work very hard, not only to compete with present problems, but to make up the lee-way in administrative matters with which it started.

One regulation which Jaffar insisted on was that the Iraq Army, unlike the army of the Hedjaz, should not have all its officers of the rank of Major-General. And in addition he insisted that every officer who joined, no matter what his previous rank had been, should go through a course at a newly-formed Junior Commanders' School in Baghdad, the instructors for which were originally found from British Army N.C.O.s. To make certain that there would be no exceptions, Jaffar himself, though Deputy Commander-in-Chief and Minister for War, went through the course, sloping arms and fixing bayonets under the guidance of a British serjeant. The first few months were unbelievably strenuous. In addition to being instructed himself, he acted as interpreter for a British officer teaching gun drill, worked as Commander-in-Chief and Minister for War, and helped to translate military text-books into Arabic.

At the end of 1921 the army consisted of 2,000 officers and men. Gradually it grew until, in 1928, there were serving some 11,000 all ranks. In these days of "universal peace," it may seem unnecessary for an army, even of this size, to be maintained in a new country, more especially when that country is distinctly poor. But Iraq has very definite military commitments. To begin with, on the north is the Turkish Empire and with no army—or a badly trained army—it would be very easy for Turkish forces, even if not mobilized, to cross the frontier and seize, let us say, Mosul Vilayet. What Europe would do, faced with a *fait accompli* of this sort, is not very

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certain, but if the Iraq army is strong enough to make such an incursion by unmobilized troops impossible, then, in order to achieve a military success, Turkey must mobilize. Mobilizations cannot be kept secret and take time, and thus time is allowed in such a case for diplomatic pressure to be brought to bear on the Turkish Government, and for British reinforcements, if necessary, to arrive.

The problem in regard to Persia is not so acute. The Persians, prior to the accession of Riza Khan, undoubtedly cast envious eyes on the Shiah holy places of Nejef and Kerbela. The Persian army, however, is not a very serious matter at present, and the Church party in Persia has declined greatly in influence. To the north of Persia lies Russia, however, and the intentions of the Soviet are by no means clearly pacific. Despite the best wishes of the Persian Government, it is not impossible that, on some future occasion, it might be led into an attack on Iraq.

The solution of the frontier problem with Ibn Saud is a much more difficult matter. The shepherds who occupy the land on the Iraq side of the frontier have relatives, and in some cases the remainder of their tribes, on the Nejd side. Raid and counter-raid have gone on for generations, and many of the raids that have taken place during the last four years have been of a retaliatory nature. A Bedouin raid is a difficult matter to compete with. A party of perhaps 2,000, perhaps 4,000, or perhaps only a few hundred men mounted on camels or horses, decide to raid a definite encampment. They move slowly to within 60 to 100 miles of their destination, and then do this last lap as hard as possible, timing themselves to arrive either just at moon-up at the beginning of the night if there is a full moon, or at dawn. The encampment is rushed and the remainder of the night or of the day is spent in collecting the loot and moving back towards their previous base. In one raid that happened last winter, a party of Bedouin, mounted on camels and horses, did 160 miles in thirty-six hours, including the raid, and the last twelve hours they were driving sheep.

Such raids, though damaging to the prestige of the Iraq Government, are very difficult to suppress. Steps have been taken to make defence posts in Iraq some thirty miles from the Frontier, at which light, rapid-moving forces may be stationed. These posts have given a great sense of security to the desert dwellers, and have, to a certain extent, limited the spheres of action of the raiders.

It will therefore be seen that it is essential for Iraq to have an army. The exact size of the army has not yet been determined, but it is probable that it will not have a peace establishment greatly in excess of its present numbers. In addition to its military functions, its presence is, in another way, proving most important in Iraq's development. The Iraq State is over 99 per cent. illiterate. The number of school teachers is very limited, and so a scheme has been

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started in the army for education. The officers in charge of platoons have been made responsible for the education of their platoons, and in the last three years the percentage of literacy in the army has risen from 0·5 to nearly 10. With the development of the scientific arms it has also become necessary to start trade schools, and tradesmen are being turned out greatly superior to their brothers in the bazaar. The army as a school is, perhaps, a new conception, and only in this kingdom of topsy turvy could one find an army with such a justification.

Now, though defence is the most spectacular problem the Iraq Government has to face, the real problem is finance. The country has potential wealth in many directions, even disregarding the oilfields, but without money these potentialities cannot be investigated or developed. The people are ignorant but intelligent—without money they cannot be educated. The yearly toll of disease, due in great measure to bad conditions, is far too high, but without money this cannot be corrected. So the vicious circle exists. Without investigation and development and education and better health, there can be no prosperity and money. Without money, there can be no investigation or development or education or improvement in national health.

In the past, the financial advice has been sound, bureaucratic, unimaginative. Loans have been spoken of vaguely—and always with the idea that a British Treasury guarantee would solve the problem. Such a guarantee, though pleasant and trouble-saving and economical from Iraq's point of view, is improbable and even possibly undesirable; further, it is unnecessary. Iraq can command the necessary capital without either falling into the hands of exploiters, or adopting dangerous financial expedients. How this may be achieved is too long for discussion here, but it may be accepted that a scheme exists which has been approved by bankers as sound.

When the financial problem has been met, then the country will develop and cease to be either a drain or a nuisance to the British Government. Even further, it is easy to imagine circumstances in which a friendly and progressive state of Iraq would be of the utmost value to the British Empire. The Arab's desire for independence is a powerful factor that cannot be omitted from the calculations of statecraft to-day. He is the occupier of the doorstep of Asia, and his co-operation and friendship and true welfare are of the greatest importance.

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STRENGTH OF TIMBER STRUTS.

By CAPTAIN O. L. ROBERTS, R.E.

INTRODUCTORY.

THE problem of the strength of timber struts has been very much discussed for many years, but the many varying formulæ devised give results differing by well over 100 per cent.

In October, 1928, the Forest Products Laboratory of the U.S. Department of Agriculture, Forest Service, in co-operation with the University of Wisconsin, published a formula based on both practical and theoretical results.

This formula is, to the best of the writer's knowledge, the most recent attempt to solve the problem and has certainly been produced after very full and careful consideration.

The results appear to clear up the problem to a considerable extent, while the allowable safe loads for short and intermediate struts are in excess of results obtained from most formulæ now in use.

At the same time the formula is too complicated for use in the field.

This article has, therefore, been written with the object of suggesting a simple formula for field use, which is as far as possible in agreement with the most up-to-date ideas.

The solution suggested is only intended for use when accurate calculations cannot be made or are not required. At the same time, it gives results which would appear very much more accurate and more easily obtainable than by the use of Gordon's formula and other similar formulæ.

OBJECT.

In designing struts for military purposes in the field, the two main factors to be kept in view are :—

(1) Sufficient accuracy to ensure reasonable economy combined with safety.

(2) Simplicity of calculations.

The object, then, is to devise a suitable formula, involving only simple arithmetic, which will fulfil the conditions of (1) above.

ANALYSIS OF THE PROBLEM.

Three types of struts are commonly recognized, namely, short, intermediate, and long struts.

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Short Struts.

The strength of a short strut depends only on the crushing strength of the timber in the direction of its length. If the safe crushing strength of the timber is known, the strength of the strut can be readily calculated.

Long Struts.

The strength of a long strut depends only on its stiffness. In this case, where small loads produce marked lateral deflection, experimental results agree very closely with values computed from Euler's formula.

Intermediate Struts.

The strength of intermediate struts depends on a combination of stiffness and crushing strength, and is, therefore, not easy to calculate accurately. Moreover, most of the struts commonly employed in engineering practice come under this category.

Many formulæ have been devised, some empirical, others based on theory, but none of them can claim to be generally acknowledged as truly applicable in all cases. It will be seen later what a great difference there is in the results computed from these various formulæ.

Slenderness Ratio.

Struts are classified as long, short or intermediate, according to their slenderness ratio. This ratio is defined alternatively as :—

(*a*) The ratio of length to least dimension.

(*b*) The ratio of length to least radius of gyration.

The latter is the more correct for general application, but is not so simple to determine. Since the radius of gyration varies directly as the least dimension for rectangular, semi-circular and circular sections, the former is quite suitable for timber columns.

The only section likely to occur in timber, for which the radius of gyration does not vary directly with the least dimension, is a hollow rectangular section.

It is, however, considered better to keep the calculations as simple as possible. It is, therefore, proposed that throughout this article the slenderness ratio shall be considered as the ratio of the length to the least dimension.

Summary.

The problem may now be summarized as follows :—

Can one simple formula be evolved which can be applied to all timber struts ?

If not, what and how many formulæ are necessary ? And what are to be the upper and lower limits of the slenderness ratio for these formulæ ?

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EXISTING FORMULÆ.

On Plate I, graphs have been drawn comparing some of the formulæ more commonly quoted. These formulæ are discussed in some detail below. In all of them the following notation applies:—

P = safe load in tons.
p = safe load in tons per sq. in.
f = safe compressive stress in tons per sq. in.
A = cross-sectional area in square inches.
l = length of column in inches.
d = least dimension in inches.
r = least radius of gyration in inches.
E = Young's modulus of elasticity in tons per sq. in.

For purposes of comparison, in the graphs, the following assumptions have been made :—

(1) f = ½-ton per sq. in.
(2) E = 220 tons per sq. in.

There is a certain amount of difficulty in comparing formulæ, some of which are based on E and others on f. As far as possible, the values chosen are such as would be in agreement for the same grade and type of timber. If the figures err in any way, the relative value of E is on the low side. This affects Euler's formula only and it thus ensures that the graph of Euler's formula does not give values of p that are too high.

In the graphs, the safe load in tons per square inch is plotted against the slenderness ratio—*i.e.*, p against $\frac{l}{d}$

F.P.L. Formula.

The formula, referred to above, published by the Forest Products Laboratory of the U.S. Department of Agriculture is :—

$$P = fA\left[1 - \tfrac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$$

The notation is the same as given above, while K is a constant, depending on the modulus of elasticity and the crushing strength.

Different values of K, E and f are tabulated according to conditions of weather and usage, and further variations given according to grade and type of timber. The value of K varies from 21 to 32.

Intermediate struts are classed as those which have a slenderness ratio between $\frac{l}{d}$=11 and $\frac{l}{d}$=K.

Thus the upper limit varies according to the timber.

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For short struts up to $\frac{l}{d}=11$, strength is calculated by direct crushing only.

For long struts above $\frac{l}{d}=K$, Euler's formula is employed.

The factor of safety for crushing stress is taken as 4, and for the modulus of elasticity as 3.

This method has been described in considerable detail, because it is the most recently published attempt by any official group to tackle the problem, because the method, in itself, appears sound, and because it may not be generally known.

Gordon's Formula.

$$P=\frac{fA}{1+a\left(\frac{l}{d}\right)^2}.$$

"a" is a constant which varies with the nature of the strut and the fixing of the ends.

In this case "a" has been taken as $\frac{1}{140}$. This is the constant for square struts with one end fixed and one end free. It will be seen that even this gives low values of p compared to those obtained by other formulæ.

Rankine's Formula.

$$P=\frac{fA}{1+\phi\left(\frac{l}{r}\right)^2}$$

ϕ is a constant similar to "a" in Gordon's formula, and is taken as $\frac{1}{2400}$.

There are very varying opinions as to the correct value of this constant, but as far as possible an average value has been chosen.

Rankine's formula is similar to Gordon's formula, except that the slenderness ratio depends on the least radius of gyration and not on the least dimension. For square struts it gives a larger safe load than Gordon's formula does.

Euler's Formula.

$$P=\pi^2 E\left(\frac{\nu}{l}\right)^2 A \text{ (for rounded ends).}$$

As stated above, it is generally acknowledged that this formula gives comparatively accurate results for long struts only.

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Straight Line Formula.

There are several formulæ of this type, all of which take the form :—

$$P = af + \beta\left(\frac{l}{d}\right)$$

Two such are :—

$$P = \tfrac{3}{4} fA\left[1 - \frac{1}{60}\left(\frac{l}{d}\right)\right] \quad \text{and} \quad P = fA\left[1 - \frac{1}{48}\left(\frac{l}{d}\right)\right].$$

Comparison of Formulæ.

From a consideration of the curves on Plate I, the following facts appear :—

1. Both Gordon's and Rankine's formulæ are very much on the safe side, especially for intermediate struts.
2. For short and intermediate struts the F.P.L. formula gives values very much higher than those obtained by other formulæ. The shape of the curve appears logical and seems to connect up rationally with Euler's formula and with the direct crushing line.
3. The F.P.L. and Euler formulæ combined could very easily, and with a considerable degree of accuracy, be replaced by 2 or 3 straight lines.
4. The straight line formula $p = \tfrac{3}{4} f\left(1 - \frac{1}{60}\frac{l}{d}\right)$ gives high values in some cases and low values in others.

Conclusions.

1. None of the existing formulæ is entirely satisfactory.
2. The F.P.L. formula is the best solution of the problem, but is complicated.
3. The F.P.L. formula could be replaced by straight line formulæ with reasonable accuracy. Calculations would then be simple.

Possible Solutions.

Before dealing with the various possible solutions, there are three points to be considered :—

Upper Limit of l/d.

There must be some practical limiting value of the slenderness ratio, which it has been found by experience unwise to exceed. From a study of various authorities, this limiting value seems to lie between 60 and 70.

The solutions considered should bear some relationship to this value.

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Short Struts.

The U.S. Department of Agriculture consider that up to $l/d=11$, there is no buckling effect. And, for example, it is quite clear that a 12" x 12" strut, 4' long, would have very little tendency to buckle.

But, if the strut were not initially quite straight, there would be some buckling effect at values of l/d less than 11. And in the field it often happens that struts which are not quite straight will have to be used.

Care should therefore be taken that too high a value of l/d should not be chosen as the limit below which only direct crushing need be considered.

Factor of Safety.

The U.S. Department of Agriculture, when dealing with the strength of struts, have to design struts for permanent or semi-permanent use. In the field it is usually only temporary structures that have to be considered. On the other hand, in civil practice, struts can usually be chosen which are initially straight, whereas in the field this will not always be possible. These two considerations balance each other to some extent.

Therefore the solution to be considered should give values in no case greater than the F.P.L. formula.

Keeping these factors in view, the following solutions appear possible :—

I.—Three straight lines.

$l/d=$ 0 to 9	$p=f.$
$l/d=$ 9 to 35	$p=\frac{5}{6}f\left[1-\frac{1}{44}\left(\frac{l}{d}\right)\right].$
$l/d=35$ to 70	$p=\frac{1}{2}f\left[1-\frac{1}{70}\left(\frac{l}{d}\right)\right].$

This solution gives relatively accurate results, but is rather complicated.

II.—One straight line and Euler.

Up to $l/d=30$	$p=f\left[1-\frac{1}{50}\left(\frac{l}{d}\right)\right].$
Above $l/d=30$	Euler's formula.

This solution is also relatively accurate, but for struts with a value of l/d exceeding 30, calculations would be complicated. Nor does it bear any relationship to the upper limit to the value of l/d.

III.—Two straight lines.

(a)	$l/d=$ 0 to 36	$p=f\left[1-\frac{1}{48}\left(\frac{l}{d}\right)\right].$
	$l/d=36$ to 66	$p=\frac{11}{20}f\left[1-\frac{1}{66}\left(\frac{l}{d}\right)\right].$

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or (b) $l/d = 0$ to 36 $\quad p = f\left[1 - \frac{1}{48}\left(\frac{l}{d}\right)\right]$.

$l/d = 36$ to 60 $\quad p = \frac{3}{5}f\left[1 - \frac{1}{60}\left(\frac{l}{d}\right)\right]$.

Both these alternatives are simpler than *I* or *II*, but not so accurate. Any inaccuracy, however, errs on the side of safety. Alternative (b) is slightly simpler than (a) and errs again on the side of safety for long struts.

IV.—One straight line.

$l/d = 0$ to 50 $\quad p = f\left[1 - \frac{1}{50}\left(\frac{l}{d}\right)\right]$.

This formula gives very good results up to $l/d = 40$, but above that errs very much on the side of safety. It only allows for the use of struts of $l/d = 50$ or less.

Summary.

Before deciding on the best solution, it is proposed to summarize these considerations.

1. Calculations should be kept simple. This can be done by using straight line formulæ.
2. Suitable straight line formulæ can be found.
3. The use of 3 straight lines is unnecessarily complicated.
4. The use of 1 straight line does not give sufficient accuracy.

For the sake of clearness, the above 4 possible solutions and the F.P.L. solution only have been shown on Plate 2.

Many variations of these straight line solutions can be made, but they cannot vary greatly from one or other of the solutions suggested.

PROPOSALS.

It is, therefore, proposed that 2 straight line formulæ should be used, and that they should be the simpler and safer of the two alternatives suggested in solution *II*, that is to say :—

From $l/d = 0$ to $l/d = 36$ $\quad p = f\left[1 - \frac{1}{48}\left(\frac{l}{d}\right)\right]$.

From $l/d = 36$ to $l/d = 60$ $\quad p = \frac{3}{5}f\left[1 - \frac{1}{60}\left(\frac{l}{d}\right)\right]$

Struts with slenderness ratios greater than 60 should not be used.

It is admitted that these solutions are purely empirical, and that a sudden change of slope occurs for which there is no justification.

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But in favour of these proposals, it is contended that :—

1. They are simple to calculate.
2. The figures obtained from these equations agree fairly well with generally accepted safe loading, and are well inside the figures obtained by the Forest Products Laboratory formula.
3. There is a reasonable degree of accuracy, without sacrificing safety. Hence there is economy of material.

Circular Struts.

It is generally agreed, as a result of both experiment and theory, that a circular strut is not as strong as a square strut of the same least dimension.

Theoretically.

The crushing strength of a strut is directly proportional to its sectional area. Therefore a circular strut is $\frac{\pi a^2}{4}/a^2$ or $\frac{\pi}{4}$ times as strong as a square strut of the same least dimension with regard to crushing only.

The stiffness of a strut is usually taken as being directly proportional to its radius of gyration. The radius of gyration of a circular strut is $\frac{1}{4}$ of its least dimension, and that of a square strut is $\frac{1}{\sqrt{12}}$ times its least dimension. Therefore a circular strut is $\frac{\sqrt{12}}{4}$ $= \frac{\sqrt{3}}{2}$ times as strong as a square strut of the same least dimension, with regard to stiffness only.

Practically.

The Forest Products Laboratory, U.S.A., consider that a circular strut of diameter "d" may be taken as equivalent to a square strut with sides $7/8d$. "d" is measured at a distance of one-third the length from the tip. If the mean diameter were considered, the square would have sides equal to about $6/7d$. Considering the constants for Gordon's formula, a circular strut of mean diameter "d" is considered equivalent to a square strut with sides $6/7d$.

Other considerations.

Generally, and especially in the field, circular struts are more likely to be bent than square struts. The tendency should, therefore, be towards a larger factor of safety.

In any case, the diameter at the tip of the circular strut must be such that the cross-sectional area will be sufficient to withstand crushing. For short struts this will be the deciding factor as to their strength.

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If this is always ensured, there is no need to consider crushing further, in deciding the relative sections of circular and square struts of the same strength.

The F.P.L. suggestion is for civil use, and under such conditions it is assumed that the struts will be initially straight or nearly so.

Gordon's formula gives such very safe values for square struts, that the allowance for circular struts may not be sufficient if applied to other formulæ.

Summary of Considerations.

1. The area at the tip of a circular strut must be sufficient to withstand crushing.
2. Apart from this, in considering relative values, only stiffness need be considered.
3. For different reasons, both Gordon's formula and the F.P.L. recommendation are not sufficiently on the safe side for field use.
4. The tendency should be to increase the factor of safety for field use.
5. Summarized the results are :—

Theory—crushing strength	$\pi/4$	=	$0{\cdot}785d$.
Theory—buckling strength	$\sqrt{3}/2$	=	$0{\cdot}866d$.
F.P.L. and Gordon's formula	$6/7d$	=	$0{\cdot}857d$.

Conclusion.

From a study of these considerations, it is thought that the allowance should give a result safer than either the theoretical relative buckling strength or the F.P.L. recommendations.

It is, therefore, suggested that a circular strut of mean diameter "d" should be considered as equivalent to a square strut with sides $5/6d$. The sectional area at the tip must also be sufficient to withstand crushing.

When the circular strut is not reasonably straight, the allowance should be reduced to 4/5 or even 3/4. But in such cases it would be better, if time were available, to consider each strut on its merits as eccentrically loaded. Calculation of the strength of a strut initially bent is comparatively easy.

In measuring the mean diameter, care should be taken to obtain the approximately true mean diameter. Spars are very often wider at the butt for a distance of 2 or 3 feet, before assuming the true taper of the tree.

Illustration.

To illustrate the effect of this suggestion, the following figures are given, using the same value in each case for the safe compressive stress :—

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According to Gordon's formula,
safe load on a 20′ – 12″ x 12″ baulk =18·7 tons
,, ,, ,, 20′ – 14″ mean dia. spar =18·7 tons
According to proposed figures,
safe load on a 20′ – 12″ x 12″ baulk =42 tons
,, ,, ,, 20′ – 14″ mean dia. spar =38·8 tons

Rectangular Struts.

The buckling strength of a rectangular strut will be the same as that of a square strut of the same least dimension.

Its crushing strength, however, will be greater.

The proposed straight line formulæ do not allow for any struts being subjected to crushing only.

It is suggested that no extra allowance should be made for rectangular struts, relative to square struts of the same least dimension.

Fixed Ends.

In the figures so far given, struts with " ends rounded " only have been considered.

In several of the formulæ at present in use a strut with " fixed ends " is considered to be able to support an increased load.

This is only true when applied to failure by buckling, as the fixing of the ends cannot, obviously, increase the strength to resist direct crushing.

Under military conditions, occasions will seldom arise when it will be safe to consider either end as completely fixed, and partial fixing has very little effect on the stiffness of the strut.

Gordon's formula makes an allowance for either one or both ends being fixed, but it is considered that these allowances are only justified because in any case the allowable loads err very greatly on the side of safety.

It is, therefore, proposed that, for all general purposes in the field, all struts should be considered as having " ends rounded."

Illustration of Results.

The following figures are given comparing Gordon's formula, the F.P.L. formula and the straight line formulæ now proposed.

It will be seen that the proposed safe allowable loads, though greatly in advance of those obtained by Gordon's formula, are still considerably less than those obtained from the F.P.L. formula.

Results of Euler's formula have not been given as these are embodied in the Forest Products Laboratory method, Euler's formula itself being used for long struts.

The following struts have been considered :—

12″ x 12″ square struts —20′ and 40′ long.
14″ mean dia. circular struts —20′ and 40′ long.

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The allowable stress for Gordon's formula and the proposed straight line formulæ has been taken as ½-ton per sq. in. In the case of the Forest Products Laboratory method, 820 lb. per sq. in. only has been taken, since this is the figure given in their table for unselected Douglas fir (dense) and unselected southern yellow pine (dense). This figure is low for temporary structures.

These results are as follows (in tons) :—

12" x 12" square struts.	20'	40'
Gordon's formula, ends rounded	9·7	2·7
,, ,, one end fixed	18·7	5·8
,, ,, both ends fixed	27·2	9·7
Proposed straight line formulæ	42·0	14·4
F.P.L. formula	48·4	17·6
14" mean diameter round struts.	20'	40'
Gordon's formula, ends rounded	10·9	3·0
,, ,, one end fixed	20·8	6·5
,, ,, both ends fixed	30·6	10·8
Proposed straight line formulæ	38·8	12·8
F.P.L. formula	51·0	19·2

SUMMARY.

It is suggested that the following method of ascertaining the strength of timber struts should be employed in the field :—

Square Struts.

For values of l/d from 0 to 36,

$$p=\frac{P}{A}=f=\left[1-\frac{1}{48}\left(\frac{l}{d}\right)\right].$$

For values of l/d from 36 to 60,

$$p=\frac{P}{A}=\frac{8}{5}f\left[1-\frac{1}{60}\left(\frac{l}{d}\right)\right].$$

Above $l/d=60$, struts should not be used.

No allowance in addition to be made for rectangular struts or fixing of ends.

Circular Struts.

To be considered as square struts of least dimension equal to five-sixths of the mean diameter of the circular strut.

ECCENTRIC LOADING.

In this article, no attempt has been made to discuss the problem of eccentric loading. It is hoped to be able to deal with this in a later article, and more especially with its application to derricks.

NOTE.—Any suggestions, addressed to F.W. & B. School, S.M.E., Chatham, would be welcomed.

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Plate 1.

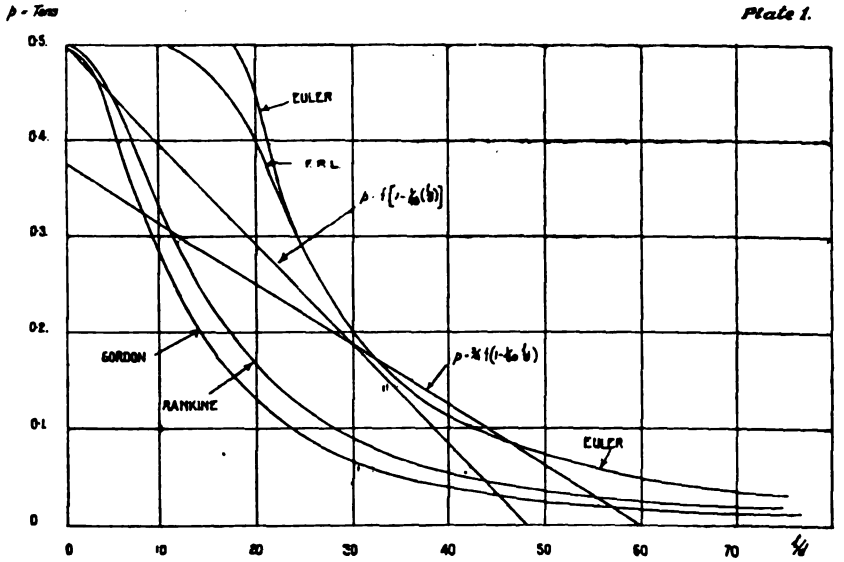
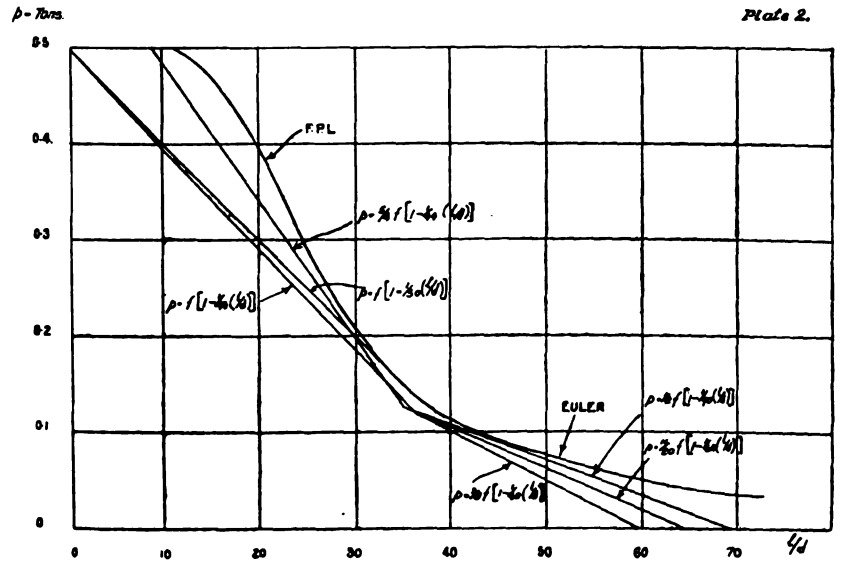


Plate 2.



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THE OBERHASLI HYDRO-ELECTRIC SCHEME.

By BT. MAJOR G. MACLEOD ROSS, M.C., M.ENG., A.M.INST.C.E., R.E.

A RECENT visit to Switzerland, and the courtesy of the Kraftwerke Oberhasli A.G., enabled me to look over a hydro-electric scheme, which utilizes the source of the River Aar to obtain a quarter of a million horse-power.

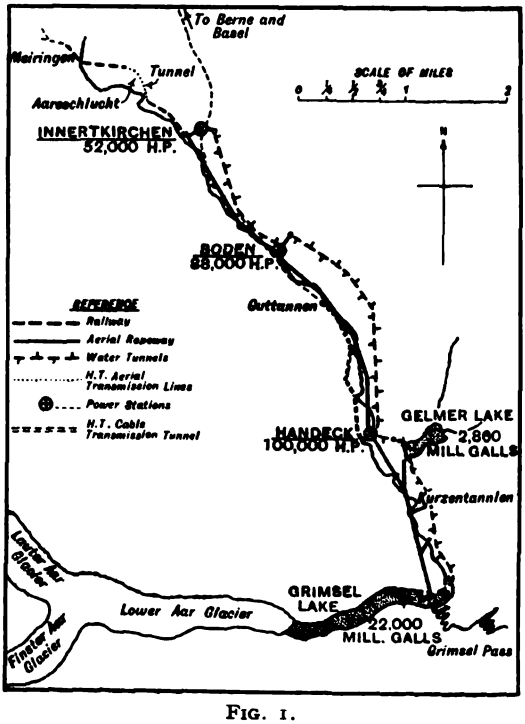

FIG. 1.

The Aar rises in several glaciers which lie below the Finsteraarhorn (14,926 feet) and the Shreckhorn (13,386 feet) and flows down the Haslithal to Lakes Brienz and Thun and thence to Berne. (Fig. 1.) For many years the potentialities of the source of this river have been recognized, and as a result of measurements taken over a period of ten years, ending in 1923, the run-off from the Unteraar glacier measured at Grimsel (6,200 feet) was found to be 52,800 million gallons annually, or sufficient to supply the City of London for 200 days. The difference in level between Grimsel and Lake Brienz is approximately 4,000 feet static, in a distance of 15 miles.

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A committee of experts was appointed to discover the best means of utilizing these natural resources, and it was eventually decided that the main reservoir should be formed at the Grimsel, near the Pass, and that it should connect directly with an auxiliary reservoir, to be formed on the site of a natural lake at Gelmer, 3½ miles away, and 200 feet lower. This second lake is fed from a catchment area, producing 18,700 million gallons annually. Finally, the water so conserved was to be brought down and passed through three successive power stations, Handeck, Boden and Innertkirchen, at levels of 4,280 feet, 2,900 feet and 2,092 feet respectively. It was estimated that these stations would produce 538 million K.W.H. per annum.

The Company interested in the promotion of this scheme is the Forces Motrices Bernoises S.A., which is a public utility company supplying Berne and Basel, and as soon as the company found the demand for power increasing, it decided to implement the works necessary for the fulfilment of the expert committee's plans, and placed a contract with the Bernischen Kraftwerke A.G., which formed the Kraftwerke Oberhasli A.G. to handle the job with a working capital of £1·2 millions.

It was decided to develop the scheme in two portions, the former to comprise the reservoirs at Grimsel and Gelmer, and the Handeck Power Station, whilst the two remaining power stations at Boden and Innertkirchen were left for later development.

The first portion of the scheme will produce 223 million K.W.H. per annum and will cost £3·3 millions, the net cost of current being estimated to amount to 0·352 pence per K.W.H., whilst on completion of the whole scheme it is hoped to reduce this figure to 0·238 pence per K.W.H.

Although the nature of the two schemes is entirely different, it may be worth while to mention that the Shannon Scheme (partial development) is estimated to cost £8 millions, and to produce 147½ million K.W.H. per annum at 1·13 pence per K.W.H. net.

Preparatory Work.

The nearest railhead to the Grimsel was Meiringen, 15½ miles away, and one of the first undertakings was the three-mile extension of this metre-gauge line, through the Aareschlucht to Innertkirchen, involving a mile of tunnelling. At Innertkirchen has been established the main receiving depot for all stores, and here, too, are housed the store and accounting staff.

From Innertkirchen to Grimsel there is a good mountain motor road, but it carries a very large volume of pleasure traffic in the months of the year, May–October, during which the Grimsel Pass is open, and the road would not have supported the added burden

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of the continuous stream of cement necessary for the constructional work. It therefore became necessary to erect an aerial ropeway over this stretch, and also from Kurzentannlen to Gelmer. (Fig. 1.)

From Guttannen the valley is narrow and rugged and the ropeway trestles have been placed on the spurs in order to avoid land and snowslides, which are the order of the day at altitudes above 4,500 feet. This ropeway is similar in design to the lately dismantled Khyber Ropeway, and has a capacity of 200 tons per 24 hours, the 12½-mile trip taking 2 hours.

Other preparatory work, in addition to barracks for the labour at all the locations concerned, comprised a funicular railway from Handeck to Gelmer, rising 1,700 feet straight up the face of the cliff, and capable of hauling 4½ tons at a time up a grade which reaches 100 per cent. maximum.

At both Gelmer and Grimsel, much contractor's railway had to be laid; at the latter location, 3½ miles were required (Fig. 5) to enable aggregate to be hauled from the foot of the Unteraarglacier to the headworks. At both these places, buildings and machinery were installed to crush aggregate and mix concrete, and at the Grimsel site an extensive system of cableways was erected to handle the concrete on to the two dams.

This preparatory work occupied three years (1924 to 1926) but in considering this it should be remembered that the working time available was actually half this figure, and that the precipitous nature of the terrain and the severe climatic conditions made the work exceptionally difficult and slow. Completion of the first part of the undertaking is anticipated in 1931.

THE GRIMSEL HEADWORKS.

As can be seen from Fig. 2, the outfall of the River Aar is to be blocked at two points near the old Hospice. All around is bare, homogeneous granite, and although the consulting geologist was satisfied that the rock was free from faults, a trial bore was driven at the site of the larger of the two dams, in the Spitallamm gorge, as a result of which his predictions were confirmed.

The necessity for a first-rate geological opinion, supported by trial bores on the dam site, was exemplified a couple of years ago by the failure of the St. Francis Dam in California, where investigation after the disastrous failure proved the site selected to be geologically unsafe.

The main dam is of the arch type and will be an immense mass of 444,720 cubic yards of reinforced concrete, to be known as the Spitallamm Dam. It will rise 377 feet above the bed of the Aar, at which height the gorge is 590 feet wide. The base, which is keyed into the solid granite, is 223 feet thick, tapering at the top

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to 13 feet, the upstream face sloping at 10 to 1, and the downstream face at 2 to 1.

In August, 1929, this dam was about 50 per cent. complete, and Fig. 3 deserves detailed study. On the left can be seen the keyways hacked out of the granite with compressed air and gelignite, whilst up this face runs a wooden ladder which is a good guide to the scale of the illustration. On the dam itself can be seen the shuttering to contain the concrete, whilst above are visible the means whereby the concrete is placed. These consist of a steel chute, suspended

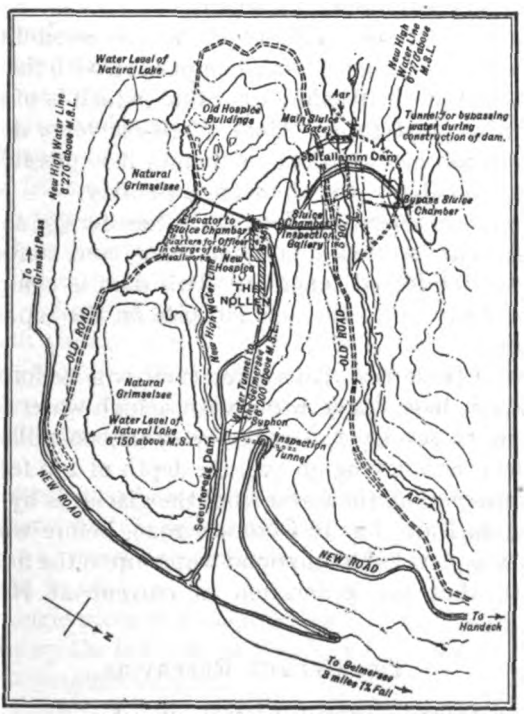

FIG. 2.

from a cable, which delivers from three points along its length through " elephant trunks " to hoppers. In addition, there are six skips of four cubic yard capacity, travelling on cables, to required points on the working floor of the dam. The vertical expansion joints in the dam can be clearly seen, whilst at the bottom at bed level is the emergency sluice for relieving any flood water.

On the Nollen, shown on Fig. 4, is constructed a steel frame and wood-panelled building. The north-east end of this building is the terminal of the aerial ropeway from Innertkirchen, and carries cement which is dumped into two huge silos. The opposite end of the top floor of this building contains the crushing and grading plant for aggregate elevated from the railway terminal shed.

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The aggregate having been crushed and graded falls into three wooden bins on the next floor, whence it is measured out in the desired quantities with cement on to an extensive system of belt conveyors which feed into batteries of concrete mixers, situated on a still lower floor of the building. The mixers feed direct into the chute and cable skips mentioned above, and a continuous flow of concrete is hereby assured on to the dam, amounting to some 3,720 cubic yards per 24 hours. This figure will be more readily gauged when it is said that it is equivalent in volume to the Lecture Theatre of the S.M.E. Main Building, Chatham.

Enormous as this figure undoubtedly is, the possibilities of placing concrete can best be gauged from a comparison with the rate obtained on the Diabolo Dam in Washington State, which is of similar design but of somewhat greater size. Here, a belt-conveyor delivery system from mixer to job has been tried out, and it is possible to place no less than 30,850 cubic yards of concrete per day.

The second, and subsidiary dam, is the Seeuferegg, shown in Fig. 4, and is of gravity section, 1,000 feet long, and containing 75,864 cubic yards of reinforced concrete. This dam is complete and will carry the roadway up to the new Hospice on the top of the Nollen, seen in Fig. 4.

By means of these two dams a reservoir will be formed, 3½ miles long, and about half a mile wide, with a high-water level at 6,271 feet above mean sea level, a capacity of 22,000 million gallons or 8,100 acre feet, and having an average depth of 270 feet.

During construction, the water from the glacier is by-passed round the Spitallamm Dam, but in October, 1929, before work ceased for the year, it was decided to impound water up to the finished level of this dam, so that the generation of current at Handeck might commence.

THE GELMER RESERVOIR.

From the Grimsel, a tunnel, 6½ feet diameter, has been driven 3½ miles through the rock at a level of 6,002 feet above M.S.L. to the Gelmer Lake, which has been formed by damming the western edge of a natural lake fed from a rich catchment area to the north and east.

All work here is completed and the dam is 1,250 feet long, contains 102,000 cubic yards of concrete and impounds water up to a level of 6,074 feet above M.S.L. (Fig. 5), the capacity of the lake being 1,050 acre feet. The illustration shows the steel staging erected to carry the travelling gantry; this will shortly be dismantled.

Theoretically, it would have been preferable that the levels of the reservoirs at Grimsel and Gelmer should be the same, but it was estimated that the cost of raising the high-water level at Gelmer the 200 feet between the levels 6,074 feet and 6,271 feet would be double

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the cost of obtaining the higher level at the Grimsel site. This provides an interesting comparison between the development costs of the two sites—the Grimsel having a narrow bottleneck with nearly vertical sides, and consequently almost ideal from the hydro-electric point of view; the Gelmer being a widely-splayed gap, the cost of blocking which increased rapidly for every additional foot rise in height.

The Handeck Power Station.

The working head available at Handeck is 1,796 feet static maximum, and 1,690 feet minimum, depending on the level of Gelmer Lake. The water from Gelmer is led to Handeck through a steel pipe having a maximum gradient of 72 per cent., set in a shaft hewn out of the granite, and nowhere less than 100 feet from the surface. It is thus protected from low temperatures and avalanche.

The Power Station, seen on the left of Fig. 6, will house four Pelton-wheel turbines, each of 30,000 horse-power, set on vertical axles on which are directly mounted the Oerlikon 25,000 K.V.A. alternators. The current is three-phase, 50 cycles periodicity, and the generation voltage is 11,000.

Opposite each alternator is a Brown Boveri transformer, having a ratio of 11,000/50,000. The transformers are of the oil-immersed, water-cooled type, and can be run out of position for inspection on a special motor-driven bogie, it being only necessary to break two connections.

In August, 1929, two power units had been completed, together with all necessary switch gear, and only awaited the impounding of the water at Grimsel to commence generation. The remaining units are well in hand.

The largest single piece of machinery to be transported by motor-lorry and trailer up the hill road to Handeck consisted of a portion of the rotor which weighed 22 tons.

The power house is a steel frame, granite-panelled, and the generator hall is served by a 90-ton travelling crane. The main doors of the building are pressed steel, and slide vertically on counter-weights.

On the right of Fig. 6 can be seen the staff quarters which are connected to the power house by a tunnel for use in the winter.

The switchboard is of the most modern design, and includes, in addition to the electrical instruments, a recording gauge, showing the water level at Gelmer; controls for the sluices at Grimsel and Gelmer, and master temperature gauges, operated by press-buttons, on which can be ascertained the temperatures of the main bearings of the generator sets, and of certain points in the ventilating and heating ducts.

The ventilating and heating system is of considerable importance

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in a station subject to such low temperatures, and it has combined with it a fire-extinguishing system, by means of which any alternator can be isolated in case of overheating or fire, and carbon dioxide may be pumped in under pressure.

In the turbine wells, a very interesting feature is the portion of cast steel reinforced pipe which connects to the four turbines. The thrust at the end of this pipe is taken by an immense monolith of concrete, and forms a most impressive bit of work.

The estimated draw-off of water from Gelmer on normal load is 235 cusecs, rising to 425 cusecs maximum, but since the plant installed can utilize 616 cusecs, one of the four units can be regarded as in reserve. The water impinging on to the paddles of the turbines is controlled both as to direction and quantity, the latter control being by means of a needle valve. Safety devices are included whereby, in case of accident to a unit, the water can be by-passed automatically direct to the tail race. From the tail race the water passes to a compensating reservoir before entering the tunnel, which leads to a point above the Boden Station.

INNERTKIRCHEN TRANSFORMER STATION.

Current from Handeck is conducted over the first three miles of the distance to Innertkirchen by means of buried cables, set in the floor of a tunnel, which is large enough to contain a narrow-gauge line and a battery-driven train, which hauls stores and staff between Handeck and Guttannen. The need for this precaution arose owing to the fact that this section of the Haslithal is subject to very bad avalanches in the winter, which would have jeopardized the continuity of an aerial transmission line in this section.

From Guttannen four sets of conductors, set on pairs of pylons, carry the current from each of the four power units, through Boden, to the open air transformer station at Innertkirchen. The four lines come in on the left of the station, next comes the bank of four Brown Boveri transformers, having a capacity of 26,000 K.V.A. and a transformation ratio of 50,000/150,000—only two transformers have been erected so far. The first switch on the line from Handeck comes next, after which the four lines are paralleled, and a double transmission line goes off to Berne and Basel, respectively 40 and 90 miles distant, over the Brunig Pass (3,317 feet above M.S.L.).

SECOND PHASE OF THE SCHEME.

In August, 1929, the Power House at Innertkirchen, which is again a steel frame with granite panels, and is covered by a 120-ton travelling crane, was complete and awaited the generating plant,

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THE OBERHASLI HYDRO-ELECTRIC SCHEME.

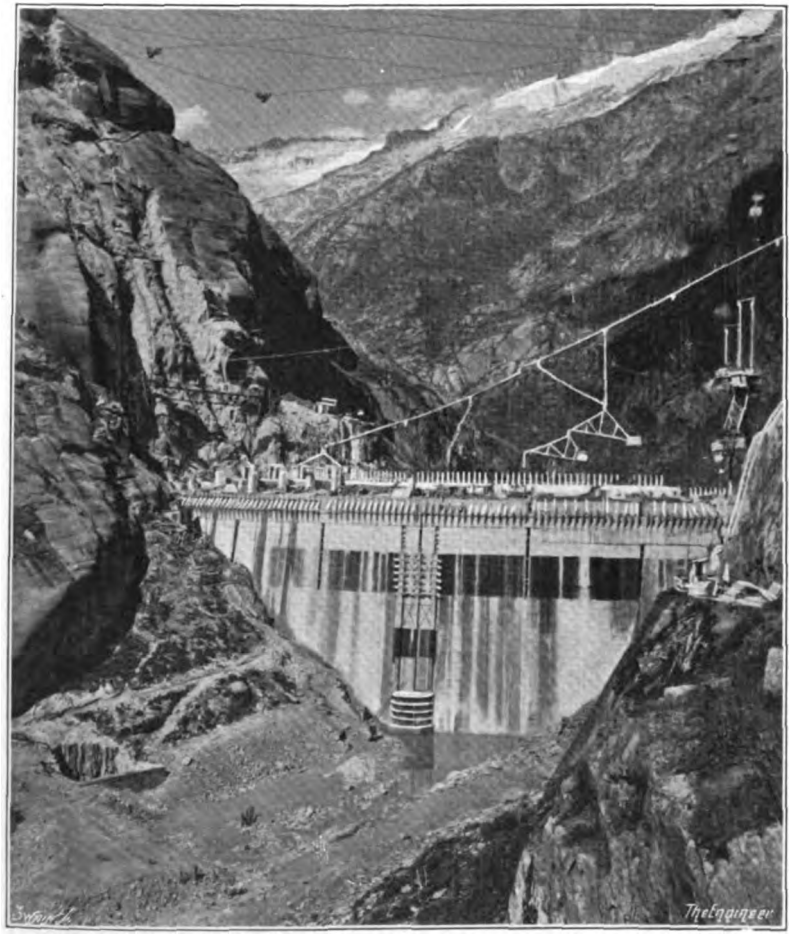

Fig. 3.—The Spitallam Dam.

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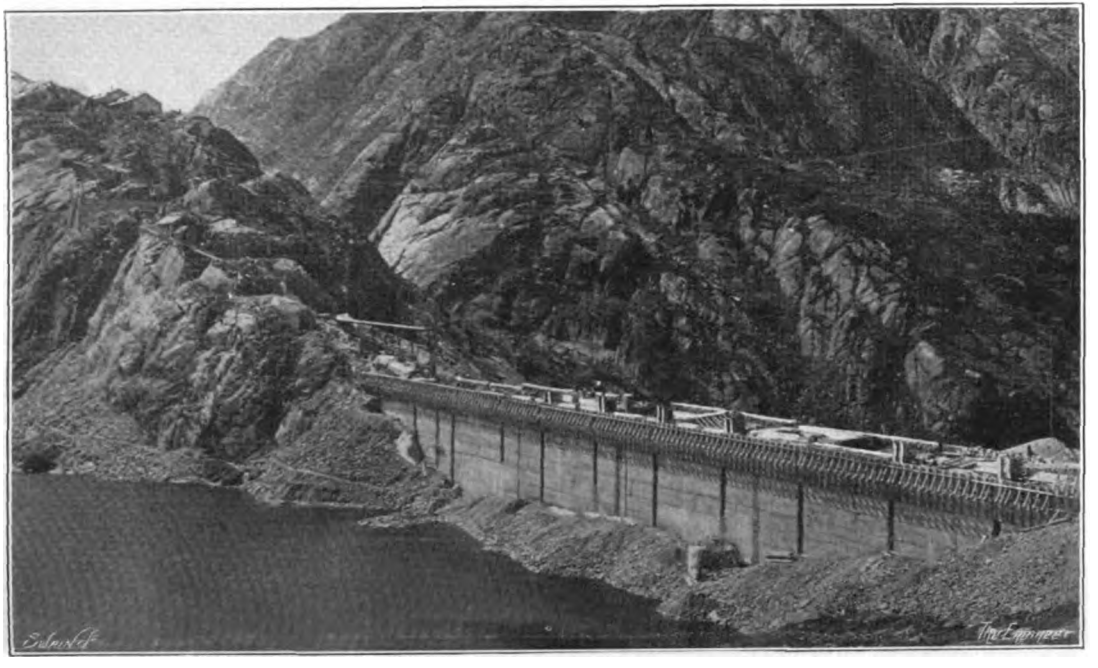

Fig. 4. – The Seeuferegg Dam.

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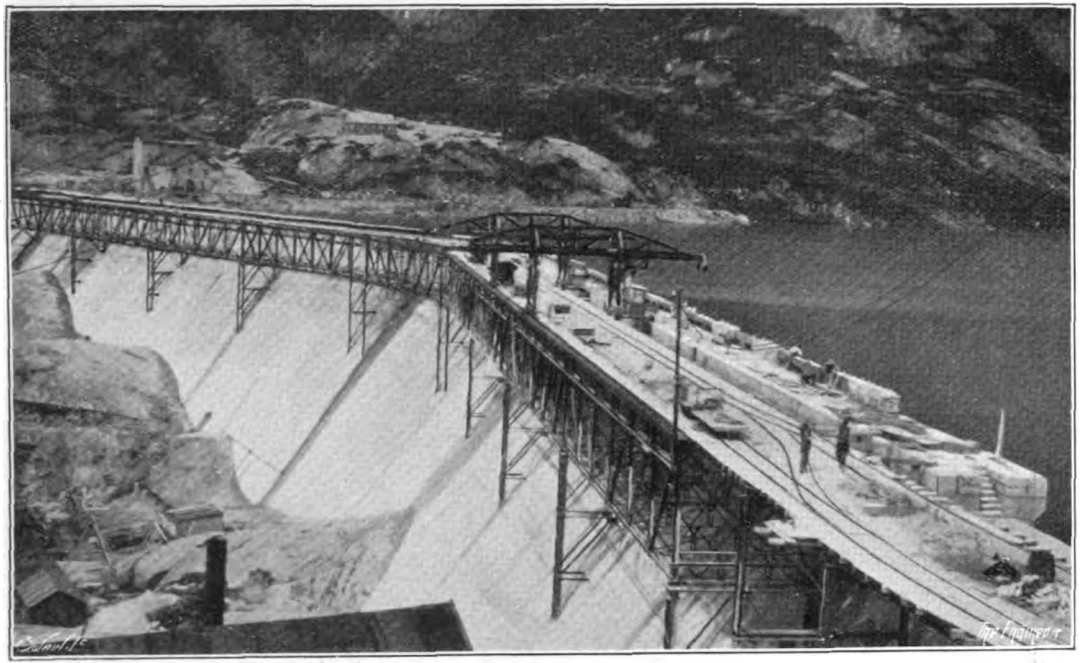

Fig. 5.—The Gelmer Dam and Lake.

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Fig. 6.—The Power Station at Handeck.

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which is to consist of four 13,000 K.V.A. alternators, working under a static head of 815 feet, and having an annual output of 125 million K.W.H. (see Fig. 7).

The water is to be led down to the turbines from the compensating tank at Boden, through a 10-foot diameter tunnel, 2·8 miles long, driven through the rock side of the valley, with a gradient of 2·2 per cent., to the pressure shaft, which will be 1,875 feet long.

At Boden, where the third power station will be sited, four 22,000 K.V.A. generators are to be installed, working under a static head

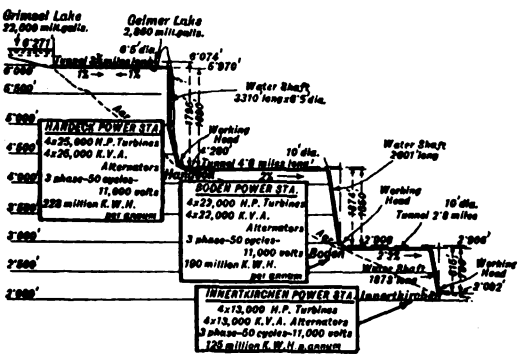

FIG. 7.

of 1,374 feet maximum, and producing 190 million K.W.H. per annum. Both this station and that at Innertkirchen will generate at 11,000 volts, and this pressure will be stepped up to 50,000 before transmission to the central transformer station at Innertkirchen. The Boden Station will be fed from Handeck, through 4·6 miles of 10-foot diameter tunnel, with a 2 per cent. grade to Boden, the pressure shaft being 2,600 feet long.

No date is available for the completion of the whole scheme, and it is probable that progress will depend on the demand for power in the industrial areas to be served.

Acknowledgments are due to Sir William Lister, K.C.M.G., for permission to reproduce Figs. 4 and 5.

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MEMOIRS.

COLONEL SIR THOMAS HUNGERFORD HOLDICH, K.C.M.G., K.C.I.E., C.B.

(*Reprinted by permission from "The Geographical Journal," March*, 1930.)

"THE death of Sir Thomas Holdich at the age of eighty-six has removed one who, at the beginning of the century, had a greater experience and a more profound knowledge of the geography and inhabitants of the North-West Frontier of India than any other living man. That knowledge and experience were founded on personal contact with almost every tribe and race that inhabit Afghanistan, Baluchistan, Turkistan, and Persia, during twenty years of service, crowded with incident military and political, on the borderland of India. When he left India he was the supreme authority on all matters connected with frontier delimitation and demarcation.

Sir Thomas was born at Dingley, Northamptonshire, on 13th February, 1843, the son of the Rev. Thomas Peach Holdich, and was educated at Godolphin Grammar School. Passing high out of the Royal Military Academy at Woolwich, he was commissioned in the Corps of Royal Engineers on 17th December, 1862, and after completing his instructional courses at the School of Military Engineering at Chatham, he came out to India early in 1865. His choice of career in India had probably been made before sailing for the East, for in less than a year he received a temporary appointment in the Survey of India, and accompanied the Bhutan Field Force as assistant surveyor in the cold weather of 1865–66. At the close of that expedition he was made permanent in the Department, and remained in it until his retirement in 1898, at the age of fifty-five.

Holdich was soon on active service again. After little more than a year in Rajputana he was selected as one of the survey officers for the Abyssinian campaign in December, 1867. Eighteen months later he returned to India and joined a survey party in Central India. It was here, I believe, that he had the narrow escape in company with Edward Leach out tiger shooting, the story of which he used to tell right up to his death as one of the most exciting moments of his long career. But this was an incident that did not compensate one

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Colonel Sir Thomas Hungerford Holdich, K.C.M.G., K.C.I.E., C.B.

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whose yearning was already for a life of active service on the frontier, and soon after he was given charge of the Vizagapatam Survey in 1877, he took furlough to England, after having been continuously abroad, it appears, for twelve years. From this furlough he was recalled to join the Southern Afghanistan Field Force in December, 1878, thus beginning his long unbroken connection with the frontiers of India, which lasted for twenty years.

When Holdich first set foot in Quetta, in the early days of Robert Sandeman, very little was known of Baluchistan, beyond parts of Kalat and the Pishin plain; even the present line of the railway was unexplored, and, to quote his own words, "only a thin line of information was marked on the maps linking up Jacobabad with Quetta and Kandahar." The Afghan War changed all this, and in many ways changed also the policy of the Army towards geographical and topographical exploration. This change in policy was due mainly to two men, Sir Donald Stewart and Michael Biddulph, the two generals who commanded the South Afghanistan Field Force. For the first time, apparently, trained staffs of sapper surveyors, both triangulators and topographers, with Indian assistants, accompanied the advanced forces in the field to carry out scientific survey, as distinct from rapid military sketches. An accurate system of triangulation was carried up to Kandahar by Maxwell-Campbell, Heaviside, and Rogers, and when that place was taken in January, 1879, Holdich, who had been in charge of the topography, following close on the heels of the triangulators, employed his men in detailed surveys towards the Helmand, Girishk, and Kalat-i-Ghilzai.

On the conclusion of peace in the spring Holdich accompanied the Thal-Chotiali Field Force, which returned to India by the previously unexplored Khojak route. The peace was, however, of very short duration. The fate of Cavagnari's mission at Kabul restarted the war in the autumn, and Holdich was ordered to join the force operating on the Khyber line. The survey officers who had been in the Kurram during the first phase of the war were almost all out of action, Samuells and Charles Strahan were down with typhoid; Edward Leach (who had won the V.C.), Tanner, and Woodthorpe had all been wounded; only Scott, who first surveyed the middle course of the Kabul river, was whole. Woodthorpe, however, was able to join the Kurram column under General Roberts, while Holdich, with Bright's force, carried his triangulation along the Khyber. The junction of the two surveys was made on the hill overlooking Bala Hissar. Surveys and rapid reconnaissances were now carried out in all directions from Kabul, until they were interrupted by the siege of Sherpur, in the defence of which Holdich and his surveyors took an active part. Subsequently he accompanied Roberts on his memorable march to Kandahar, but, as might be expected, the pace was too hot for much survey work. For his

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services during the two Afghan campaigns, Holdich was mentioned in dispatches and promoted brevet-major.

Early in 1881 the Wazirs raided Tank, and a force was called into being at Dera Ismail Khan to punish the offenders. It was divided into two columns, to the northern of which, under General John Gordon, Holdich was attached as surveyor and triangulator. While Gerald Martin, with the column under General Kennedy, ascended Pre-Ghal, the highest mountain in Waziristan, and triangulated to the south, Holdich, with an escort from the northern column, was the first white man to ascend Shuidar, the second highest, whence a fine view was obtained as far as the Safed Koh to the north, dividing the Khyber from the Kurram. It is of interest in these days, when Shuidar and Razmak are so easily accessible, to remember that Holdich accompanied the first British force to reach both places.

The results of this little and almost forgotten campaign—so forgotten that it was asserted in 1927 that neither Pre-Ghal nor Shuidar had been climbed—were most important from a survey point of view, and Holdich was quick to seize the opportunity. The policy of sending explorers into forbidden country was revived. Surveyors, both British and Indian, were trained by Holdich as explorers, and, often without the knowledge of our own political officers, were encouraged to cross the border. Their rapid and surreptitious reconnaissances—in these days we rather look on them as "tip-and-run" surveys—based on the points fixed by Martin and Holdich, afterwards proved most valuable. Unfortunately, no history has ever been written of the exploits of these men, and but for scattered references to such as McNair, Abdul Subhan, the Bozdar, and a few others, it is almost impossible to ascertain details.

We find Holdich next in charge of the Kohat survey, but not for long. In 1883 he was placed in charge of the Baluchistan Survey Party, and he was officially, according to the Survey of India records, in command of this party until his retirement.

In the very year he took over charge, an opportunity came for another useful extension of frontier survey and geographical knowledge. The Shiranis had been blockaded for some two years without any effect, and it was decided to send a small "survey promenade" into their country, more with the object of showing them that they were not beyond the reach of punishment than for any other reason. It is, I think, admissible to assume, though there is no official record of the fact, that it was Holdich himself, with his burning desire to turn every faint opportunity of gathering knowledge to full advantage, who proposed and argued this little expedition into being. Only the Khiddarzai clan were recalcitrant: and they lived in the neighbourhood of the Takht-i-Sulaiman. The Takht is a high hill, commanding a fine view to the west and south; the way to it leads through the Dabarrah defile. The combination of circumstances led

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the Khiddarzai to shout defiance, and Holdich to accept the challenge. The actual capture of the enemy's position on the Takht-i-Sulaiman was due to Holdich, who, while out with a plane-table, discovered an unguarded but difficult route by which an ascent could be made to the summit. Guided by Holdich in the night, the position was turned and captured without a single casualty.

The highest point of the range was climbed and rapid triangulation executed from it and a neighbouring peak. Forty thousand square miles of new country were within view, and points scattered over this area were fixed by which the " tip-and-run " process could be continued.

By 1884 Holdich was already a very experienced and efficient frontier surveyor, desperately anxious to leave no blank space unfilled upon the map. And like all frontiersmen of the day, he viewed with intense suspicion the steady advance of the Russian across Central Asia. The " Russian Menace " was on everyone's lips. In February of that year, while England was occupied in the Sudan, the way was apparently being prepared for an advance from Merv across Afghanistan. The Amir, jealous of his eastern and southern frontiers, appeared negligent of his Herat border, and it became imperative for the British to call a halt to Russian designs. The outcome of diplomacy at St. Petersburg and London was the formation of the unwieldy Russo-Afghan Boundary Commission, to assemble on 13th October, 1884, at Sarrakhs, the point where Russia, Persia, and Afghanistan met. Holdich was placed in charge of the survey party and marched up from Quetta *via* Kandahar and the Helmand. The old boundary between Turkistan and Afghanistan was extremely vague, and though the Russians had pushed reconnaissances forward and had a good idea of the geography, our own maps were a complete blank. The survey work accomplished by the inadequate staff under Holdich was amazing. By various " technical expedients," as he himself called them, triangulation was taken from the neighbourhood of Kandahar to the Helmand, and thence through Western Afghanistan as far as the Hindu Kush near Herat. It was carried along the frontier, and on it was based not only the British but also the Russian topographical surveys: and from the eastern end it was connected across the Hindu Kush again with the previous work near Kabul. The work of this Commission, undertaken by Holdich, Gore, and Talbot, with only three native assistants, is still reproduced in text-books, as an example of how such survey should be carried out. At the end of it Holdich had some hard words to say about the political organization of the Commission; but it speaks much for his own tact and capability that, in spite of the scientific rivalry between the two survey camps, the Russian and British surveyors worked throughout in the utmost harmony, even when people at home had begun to rattle their sabres.

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The frontier laid down by this Commission has been respected to this day.

For his services on the Commission Holdich was promoted brevet-lieutenant-colonel in 1887, and was awarded the Gold Medal of the Royal Geographical Society " in consideration of the services he has rendered to Geographical Science by his surveys in Afghanistan."

On the conclusion of the Russo-Afghan Boundary Commission, Holdich found himself back in Baluchistan at the time when Sir Robert Sandeman was carrying out his policy of peaceful penetration and settlement. At the end of 1889 he accompanied Sir Robert on the political promenade known as the Zhob-Gomal expedition, which closed the back door to the Sulaiman tribes. The whole of the Zhob valley and much of the Kundar were surveyed and the site of Fort Sandeman was selected. For the next year or two Holdich, now promoted brevet-colonel, was engaged in organizing the surveys of Southern Baluchistan and Makran, the triangulation of which was undertaken by his assistants, Talbot and Wahab. Holdich himself gained an extensive knowledge of Makran and the Persian coast, and surveys were extended as far as Jask and Bandar Abbas.

In 1892 he was appointed Superintendent of Frontier Surveys, and it was in this capacity that he was called upon to organize the various survey parties for delimiting and where necessary demarcating, the line laid down in the Durand Agreement of November, 1893. The actual work in the field in connection with this agreement was not completed till 1896.

Holdich was an opponent of the Durand Line policy from the start. He always maintained that the presence of a surveyor or topographer, who knew the ground from personal observation, among the advisers of Government, would have prevented some of the errors that were made owing to lack of geographical knowledge, and the consequent political troubles on the border, both during and after demarcation. He never agreed with the policy of defining an easily penetrable frontier-line behind the independent tribesmen. As long as there was no boundary west of the tribes, we could, if necessary, follow up raiders and punish them: the boundary line did not prevent intercourse between the Amir and the tribes, but merely formed the frontier of a sanctuary, which we bound ourselves not to violate. Holdich, an ardent admirer of Sandeman's methods, maintained that to do any real good, military posts connected by good communications should be maintained at the " back door " of the tribal tracts, and so prevent the escape of marauders into the Afghan asylum. That was long before the advent of motor cars and aeroplanes, but it is interesting now to see those early ideas of Holdich in force to-day, though modified by modern conditions.

South of the Khyber the work of demarcating the line was divided into three sections. Holdich placed the Kurram party under Captain

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Macaulay, the Waziristan party under Major Wahab, and the long Baluchistan section, stretching westwards to the last pillar on Kuh-i-Malik Siah, the tri-junction of Persia, Afghanistan, and Baluchistan, under Captain Ranald Mackenzie, with Tate as his assistant.

Holdich himself, who had been awarded both the C.I.E. and C.B. in the early part of the year, accompanied Mr. Udny on the Kunar Valley Delimitation Commission in December, 1894. Once more he took the Khyber route towards Kabul, and crossing the Kabul river at Jalalabad ascended the Kunar river to Arnawai, the disputed point. It was here that they were to await the arrival of Captain Gurdon, the political officer in Chitral, who was to represent the interests of that state during the demarcation of the frontier between it and Kafiristan. The trouble which broke out in Chitral and the siege of that place hardly concern us here, for in spite of the attitude of the Afghans, Udny and Holdich carried on the work of demarcation and survey and completed it up to the Dorah pass by the following April.

The actual survey work was disappointingly meagre, in spite of the efforts of Holdich himself and his assistant, Lieut. Coldstream, simply for the reason that the Afghans obstinately refused to allow any work to take place that was not absolutely necessary for the delimitation. It is not till 1929 that any error has been found in this frontier, and that error lies in the section of it beyond the Dorah pass which was accepted as correct by both the Afghan and British Commissions.

Hardly was Holdich back from these duties when he found himself appointed as chief survey officer on the Pamir Boundary Commission, with Major Wahab, whose work in Waziristan was finished, once more his assistant. Unlike the other boundary settlements included in the Durand Agreement, the demarcation of a boundary on the Pamirs was necessitated by the principle that at no point on the earth's surface should the land frontiers of England and Russia meet. The Amir was therefore given the small strip of Wakhan, a "long attenuated arm of Afghanistan reaching out to touch China with the tips of its fingers." This narrow springless buffer, a bare eight miles wide at one spot, is all that separates Russia and Britain in the East; and it was the northern edge of this buffer that was demarcated. The work proceeded without a hitch; the Great and the Little Pamirs were surveyed in detail; and the surveys and reconnaissances of Holdich were connected by triangulation carried out by Wahab, based on resection to the distant peaks already fixed from the south. When the geodetic link was forged between India and Russia eighteen years afterwards, the difference between the common points of the two triangulations averaged only five seconds of arc in latitude and three seconds in longitude.

The Russians and British parted on the Pamirs on 12th September, 1895. On his return, Holdich was immediately appointed Chief Commissioner of the Perso-Baluch Boundary Commission, to demar-

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cate the frontier west of Baluchistan and Makran, with Colonel Wahab as his chief survey officer. Holdich was now able to put into practice the lessons he had learnt during the many boundary commissions he had been on. He already knew much of the ground, surveys had already been carried up to and along much of the frontier, and he had himself studied the characters of the men with whom he had to negotiate. These factors were of enormous advantage to him and enabled him to complete the demarcation most expeditiously before the hot weather set in. For his services to India on this commission Holdich was made a K.C.I.E.

The year 1897 saw the frontier ablaze from Waziristan in the south to Swat on the north. Once more Holdich had to find officers and surveyors to accompany each column that penetrated to the tribal areas. With his intimate knowledge, he was able to direct the efforts of his best assistants to the regions where the maps were "blankest"; and in 1898, while he was personally engaged on the Tirah campaign and reached the fatal age of fifty-five, decreed by the Government of India to be the age of inutility for Survey officers, he handed over his command in the field to his old friend Colonel Wahab.

When Holdich left the frontier there was hardly a corner of accessible ground on it that he had not seen. His strict scientific training, his capacity to endure the extremes of heat of baking deserts and the cold of Himalayan heights, his adventurous enjoyment of tight corners, all combined to make him an example to his successors on the frontier. His many frontier experiences rendered him most valuable at headquarters, where his push and tact and influence ensured that no opportunity of acquiring topographical information was missed. His view was that, when not actually required in the field, it was his job to see that his subordinates had every chance to do their job efficiently. The fact that surveys still continue on the frontier is due to the ever-increasing needs of peaceful development. Maps of larger scale, of greater exactness and detail, contoured for the alignment of roads and railways, and not merely for the punishment of marauding tribes, are required to-day, and our frontier surveyors are still hard at work. We find little blunders, necessitated by the "tip-and-run" circumstances of Holdich's time. To-day the frontier is at peace, and the back doors are connected by roads. The motor, the aeroplane, and the survey camera are there to assist us. The tribesman, at any rate in bulk, rarely scampers to his *bast* behind the Durand Line.

It must not be supposed that Holdich at the age of fifty-five closed his interest in frontier matters. Though his talents were employed in various fields for many years to come, those of us in the Survey of India who had the honour of meeting him long after he had left us always found him well up in all that concerned the Indian frontiers.

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It was not till then that he had time to put his experiences in print for the benefit of his successors. *The Indian Borderland* appeared in 1901; *India* and *Tibet* in 1904 and 1906; *The Gates of India* in 1909; and *Political Frontiers and Boundary Making*, a summary of all his accumulated wisdom on the subject, in 1918. Many of these are delightfully illustrated by his own sketches. That his interest never waned till the very end may be instanced by the fact that on 5th October last, less than a month before he died, he wrote me a letter asking me to find out what had become of a certain explorer, and of the report that he had taken down from the explorer's lips in 1884. A nephew of the man was traced and the manuscript found a few days after November 2nd. Sir Thomas Holdich was a Founder Member of the recently formed Himalayan Club and a generous donor to its foundation fund and library. The last words in his letter expressed a wish for the prosperity of the Club."

KENNETH MASON.

"Perhaps the most important of all Holdich's work was his connection, after retirement, with the Chile–Argentine Boundary. The protracted dispute between these two countries over their common frontier in Patagonia, which on more than one occasion nearly led to war, arose from the ambiguity of their Boundary Treaty of 1881, which defined the frontier as following the highest crests of the Andes along the line that divides the waters which flow into the Atlantic from the waters which flow into the Pacific.

For a distance of some 900 miles in the northern portion of the boundary, a lofty unbroken mountain chain also traces the continental water-divide, but this unbroken ridge ends at Mount Lanin (about lat. 40° S.), and from that point southward, for another 900 miles, the mountain system is a jumble of detached massifs, often separated by great lakes lying transversely to the main axis, and sometimes cut through by deep gorges, through which flow westward to the Pacific considerable rivers which have their sources far out in the Patagonia pampas to the east. It will be seen, therefore, that the actual geographical conditions did not by any means conform with the terms of the Treaty, so far as the southern half of the frontier was concerned.

The Chileans claimed as a frontier the continental water-parting in its entirety, in accordance with their interpretation of the Treaty of 1881. The Argentine case, on the other hand, was a closely reasoned argument in favour of a boundary following a series of high detached peaks as constituting the main range and equivalent to the line of the highest crests mentioned in the Treaty.

After many years of discussion, which at times nearly led to open rupture between the two countries, the governments concerned, with

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great good sense, decided to submit the whole matter to arbitration, and invited the British Government to undertake the task. This led to the appointment of an Arbitration Tribunal, in 1900, composed of Lord Macnaghten, a Lord of Appeal, as President, Major-General Sir John Ardagh, the distinguished head of the Military Intelligence Department, and Col. Sir Thomas Holdich, as members, with Major E. H. Hills, R.E., as secretary. In view of the divergence of the claims, and the conflicting and often contradictory evidence adduced, the Tribunal felt that an examination *in situ* of the region in dispute was the only means of arriving at a decision on the numerous points submitted to it. This mission fell to Holdich. He embarked for Buenos Aires with four officers as assistants on 31st January, 1902.

The examination of various portions of the frontier which the Tribunal had found difficult to decide upon was carried out by the different officers of the mission, while Sir Thomas himself crossed to Valparaiso, where he embarked on a Chilean cruiser. Eventually he arrived at Puerto Montt and, in company with the Chilean Boundary Commissioner, Dr. Hans Steffen, crossed the Andes by the low pass at Perez Rosales to Lake Mahuel Huapi, where he met the Argentine Commissioner, Dr. Francisco P. Moreno, the well-known Patagonian explorer. Thence he started southwards, making long marches by the easiest available routes, eager to get into touch with his southern parties before the winter set in. He soon established cordial relations with his mixed following, his impartiality, his friendly demeanour, his keen interest in the work of the surveyors, his determination to complete his task in spite of natural obstacles and vile weather, all combining to make an unqualified success of the journey. He concerned himself with the physical aspects of the line of the continental water-divide as an international boundary, which he found, as he expected, to be an absolute negation, in many parts, of the principle that such a frontier should be easy to see and difficult to cross. Thus it remained for him to select for the consideration of the Tribunal a line that should possess, as far as possible, the requisite physical characteristics and one that should not create any inaccessible enclave, mere occupation, in his opinion, offering no basis for arbitral consideration. The parties then assembled in the neighbourhood of Lake Buenos Aires and marched across the Pampas to Comodoro Rivadavia, where the mission embarked for Buenos Aires, just escaping the oncoming winter, which in these latitudes is very severe.

On Sir Thomas's return to England his recommendations were considered by the Tribunal and their definition of an agreed boundary line was embodied in an award signed by H.M. King Edward VII. in November, 1902.

The frontier as awarded followed a series of lofty mountain ranges, crossed rivers at gorges and avoided giving to either country any useless, because inaccessible, area. The award was received with the

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greatest satisfaction by both governments concerned, who have observed it scrupulously ever since. The immediate result was a Treaty of Peace and Disarmament between Chile and Argentine which still exerts a beneficent influence over their mutual relations.

The award met with but little criticism in the popular press, for both countries very soon realized that each had received all it could reasonably hope to make use of. Their appreciation has greatly increased with the passage of time.

On the successful conclusion of the arbitration Sir Thomas was awarded the K.C.M.G. For him, however, the conclusion of the matter had not yet been reached. There still remained the actual demarcation on the ground of the boundary so awarded. Here and there, especially in the south, in the otherwise unmistakable line there were a few points, certain mountain passes, and river and lake crossings, and the portion of the line at the southern extremity, where the governments of Chile and Argentine felt that friction might arise if the boundary marks were not set up by independent authority. They accordingly invited Sir Thomas to return to South America for this purpose in the ensuing summer. This he did, again accompanied by a party of officers.

For purposes of demarcation the frontier, where it did not actually follow the crest of the Andes, was divided up into sections and allotted to the various officers of the Commission who actually superintended the erection of the boundary pillars in the presence of representatives of the two governments.

The writer, who was present with Sir Thomas in South America, can testify to the fact that the success of this undertaking was very largely due to the power he possessed of conciliating divergent elements where difficulties had to be smoothed over. He was endowed with a personal magnetism not often met with.

It is not too much to say that at the present date, twenty-seven years after the arbitration, the name of Holdich is held in high esteem in both Chile and Argentine, while certainly few things gave him more pleasure in his later years than the thought of the enduring peace that has prevailed ever since, due, in no small measure, to his labours."

H. L. CROSTHWAIT.

Sir Thomas Holdich was closely connected for many years with the activities of the Royal Geographical Society. He had completed 25 years of continuous service on the Council when he retired from it in 1923, and he was President from 1917 to 1919.

He died at Merrow, near Guildford, on 2nd November, 1929.

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LIEUT.-GENERAL SIR HERBERT CHARLES CHERMSIDE, G.C.M.G., C.B., COLONEL COMMANDANT, R.E.

HERBERT CHERMSIDE was the second son of the Rev. R. S. C. Chermside, Rector of Wilton, Salisbury. He was born on July 31st, 1850, went to Eton as a colleger in 1860 and acquired a high standard of classical knowledge. Going thence to Frost's and Wren's—everybody used to go to a crammer in those days before confronting the examiners—he picked up a good grounding in mathematics, so that he passed easily at the head of the competitors in the examination for the R.M.A.

There is no record as to whether he specialized as a " dry-bob " or " wet-bob " at Eton ; but probably as the latter, for he told the writer, in after years, that he had emulated Byron and Leander in swimming the Hellespont ; and it has since transpired that he won many prizes as a swimmer and oarsman.

The result of the examination for R.M.A. revealed that the number of admissions was unprecedented, some 56 in all, with Chermside, then aged 17, a thousand marks ahead.

The batch included many whose names are household words to us ; but during the course at the R.M.A., which in those days extended over two and a half years, there were periodical examinations that eliminated a large number, so that the batch on passing out was reduced to about 30, out of whom about 24 got R.E. commissions, with Chermside easily at the top.

One of his contemporaries remarks that Chermside, besides being a brilliant scholar in almost every subject he took up, without in any way being characterized as a bookworm, was endowed with a marvellous memory that enabled him to recapitulate almost page by page any book he had read. For examination purposes this undoubtedly confers immense power and Chermside was able to apply it to the study of Hindustani, although he had not touched the subject in the entrance examination, and succeeded in outstripping those who had. It may be readily believed, then, that in after years, when Chermside had spent a great deal of his service in the Middle East and had acquired Arabic and Turkish, that, as was related by the late Sir Lintorn Simmons, he was enabled to correct the interpreter in the middle of a proclamation in Crete. But this is anticipating.

The principal incident of note, when the subject of this memoir was at the S.M.E., arose when certain adventurous ones received permission in 1871 to visit Paris during the disturbances generally

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Lieut.-General Sir Herbert C. Chermside, G.C.M.C., C.B.,
Colonel Commandant, R.E.

Photograph by Wiley, Brisbane.

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known as the " Commune," when the Communists, then known as " Communards," were holding Paris against the regular French troops. They found their way to Versailles with some difficulty while the bombardment was in progress, and sneaked in after the French regulars had entered Paris and were busy street fighting. Some slunk back the same night, but Chermside and Noel elected to remain, were taken prisoner, treated as English R.E. officers assisting the insurgents, and were to be led out to be shot next day. Luckily, they managed to get in touch with Lord Lyons, our Ambassador, and eventually only succeeded in getting out of Paris in the guise of Queen's messengers, with letters to the British Government.

A less exciting form of activity was the practice of walking tours, when he and two others of his batch, accompanied by a number of dogs, would set out on Fridays, after lecture, and cover about 80 miles by Sunday evening, with no other impedimenta than light knapsacks. They thus became acquainted with the old posting houses in Kent and Sussex. Noticeable amongst the dogs was a magnificent mastiff, which had been given to Chermside on condition that it was not " shown."

After a spell of ordinary duty in Ireland he disappeared, according to his record of service, on the unprecedented period of home leave of 155 days in the spring of 1873. In reality, to take part as a photographer in an expedition to the Arctic Regions (in the ship *Pittsburg*), organized by Mr. Leigh Smith. One incident is that some Swedish explorers got astray from their ice-bound ship and there was fear of their starving. So Chermside and a companion set out and located the party. It is possible that some of the photographs, which were developed by Capt. Abney at the S.M.E. Photo School, may be still in existence.

Then a further spell at Chatham on H.M.S. *Hood*, the home of the Submarine Miners, and then to Portsmouth and Devonport for practical application of the then budding science of coast defence by submarine mines. It was in this last-mentioned station that, brought into contact with the sister branch of the Service, the characteristic trait in his character was brought to the test.

It had been remarked by his fellow subalterns that in general conversation—no matter what the subject broached—Chermside had always something to say, not in a dogmatic way, but indicative that he knew what he was talking about.

One day he was away otter hunting on the moors, when *The Times*, which arrived late in the day, appeared with an important speech by Lord Goschen on " Indian Currency." It was quite impossible for Chermside to have read the publication, and all in the mess agreed to read it up and broach the subject when he appeared in the evening, to see whether he would be able to participate in the conversation.

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They were defeated, for Chermside not only showed himself well acquainted with the subject but even elucidated some points that had appeared obscure to his messmates. This characteristic remained with him throughout his life and we have further evidence from a quondam staff officer of his, who says :

> " His mind was a perfect encyclopædia of knowledge, which to me was very attractive. I doubt whether you ever knew, on talking to him, what he really thought himself. He never laid down the law, but would present a subject in all its aspects and leave you, in the end, wondering what view he himself thought the right one. It was the same in his correspondence."

His real career began when he was ordered on foreign service in 1876, never to return to home service till he was a Major-General, after a lapse of 23 years.

With many other British officers he was selected for duty in Turkey. What that duty was can only be revealed by searching the intimate history of the Middle East at that time. Clouds were brooding over the Balkans and Russia declared war on Turkey. Our old ally was in danger and Constantinople appeared to " All Europe " to be the objective.

Heated debates took place in the Mother of Parliaments, and such expressions as " The Unspeakable Turk " and " Bulgarian Atrocities " found their way into the papers. Names like the Shipka Pass, Valentine Baker, Plevna and Osman Pasha became familiar to British ears.

The Prime Minister, Lord Beaconsfield, was all against abandoning our old ally. Lord Salisbury demurred at an alliance with Turkey, and so the debate went on. But what could statesmen do to unravel the tangle when the man in the street, wending his homeward way from the debate of amateur politicians in the local " pub.," proclaimed in no uncertain tones that :

> . . . And while we're Britons true-u-u
> The Rooshians shall not have Constantino-o-o-o-pul !

So Northcote voted a credit of six millions, early in 1878, and the writer, who was then at a remote small garrison in India, remembers a sudden concentration of rolling-stock in the local railway station marked in chalk " Lahore," or " Bombay."

In a few days' time orders arrived. An infantry regiment was entrained and whisked off to Bombay, and we who remained began to furbish up our camp equipment and prepare ourselves for action somewhere. The next we heard of our infantry comrades was that they were at Cyprus and other troops had landed in Malta. The Fleet was at Besika Bay.

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Then the Powers intervened. The Russians were arrested in their march on Constantinople. There was a conference at Berlin and Beaconsfield crossed the Channel on his homeward way on the *Calais Douvre*, and was received by enthusiastic crowds who vainly demanded a speech. It is said that he popped his head out of the window of his railway carriage just as it was moving off and announced: "I bring you peace with honour."

So Chermside remained on in Turkey, sheathed his sword and set about demarcating boundaries. This carried him on till June, 1879, when he joined Sir Charles Wilson, R.E., as Military Vice-Consul in Anatolia.

Egypt.—It may be remembered that in the XVth century, Sultan Selim of Turkey wrested the control of Egypt from the Arabs, and it became vested in a Viceroy under the suzerainty of The Porte. The Treaty of London, in 1841, while recognizing the suzerainty of The Porte in principle, secured the virtual independence of the Khedive and made his dignity hereditary. But the enterprises of Mehemet Ali so embarrassed the finances of the country that the English and French had to intervene and establish a joint control.

In 1869, the Suez Canal was opened for traffic, due to the enterprise of Ferdinand de Lesseps, a French Engineer, who conceived and carried out the project which had hitherto baffled previous undertakers. Thus was opened for the British and French an all-water route to Bombay and eliminated the tedious overland journey from Alexandria to Suez.

The finances of Egypt always appear to have been in a precarious state and in the winter of 1875–6 Lord Beaconsfield, then British Prime Minister, seized on the opportunity of securing for the British Government the preponderating number of shares in the Canal.

When, in 1881–2, Colonel Arabi Pasha raised the standard of revolt, joint fleets of Britain and France lay off Alexandria to protect their respective interests. The French diplomatists, after some discussion, declined to go on with the job, and left the British a free hand to occupy the Valley of the Nile and to protect the Khedive. It was at this juncture that our forces, under command of Lord Wolseley, overran and occupied Egypt, as they do more or less to this day.

To take his share in these operations, Chermside was hailed with his Chief to take up a post on the Staff of the Expeditionary Force as Military Attaché to Her Majesty's Agency in Egypt, though, according to the *Quarterly Army List*, he is shown as D.A.A. and Q.M.G., Egypt. Possibly designed as a basis for regulating the pay of the appointment. Whatever his position may have been, he came under the notice of Sir Evelyn Wood, the first English Sirdar, who

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selected him to command the first battalion of the reconstituted Egyptian Army.

It is outside the scope of this memoir to deal with the Mahdi's* revolt in the Soudan, beyond reminding those unacquainted with this phase of developments in Egypt that the mission of General Gordon to Khartoum was to evacuate the Soudan and withdraw the garrisons left behind by the Egyptian Government, with their wives and families.

This eventuated in Gordon being shut up in Khartoum and the abortive expeditions up the Nile and to Suakin dispatched by the British Government, in hopes of rescuing him and saving the garrisons.

When the expedition, under Sir Gerald Graham, V.C., landed near Suakin in 1884, Chermside was one of the British officers engaged in the force and after withdrawal of the British troops he remained with his battalion, in command at Suakin, May 10th, 1884, and was appointed Governor-General of the Red Sea Littoral in October.

Apart from incessant minor engagements with the surrounding Arabs, he undertook the difficult and delicate task of negotiating with King John of Abyssinia for the relief and withdrawal of the Egyptian garrisons scattered in outstations adjoining the Abyssinian border. This was in pursuance of the Treaty,† signed at Adua, on 3rd June, 1884, by which King John was to receive considerable accessions of territory and other material advantages after he had facilitated the withdrawal of the beleaguered garrisons.

The negotiations were long drawn out and involved the dispatch of many messengers and display of much patience and tact. Rifles and dollars were lavished on King John, but it was not till Chermside had dispatched Saad Effendi Rifaat as Egyptian Commissioner in Abyssinia to assist in the movement, that a force was got ready. It left Adua on January 27th, 1885, defeated the Arabs surrounding Galabat and released some 3,000 souls, who reached Massawa at the end of May, there to meet, also, the troops of Amadib and the garrison of Senhit.

Meanwhile, Graham's second expedition arrived at Suakin, March to May, 1885, and though three battles were fought, nothing further was accomplished towards stopping the progress of the revolt; Kassala still remained unrelieved and finally had to surrender on June 30th, 1885.

The garrison of Gera, which had been besieged for some months, was, however, extricated by the Abyssinians on July 22nd, 1885, the Egyptian soldiers, moreover, being clothed and fed by King John. In fact, of the posts on the Abyssinian frontier, the only one which

* Mohammed Ahmed Ibn Sayid, boat builder, born at Dongola, 1848.

† This treaty became known as the Hewett-Mason Treaty and had been negotiated by Admiral Hewett and Mason Bey (the latter an American officer in the Egyptian Service) with King John of Abyssinia.

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fell into the hands of the Dervishes was Gedaref, which was surrendered in April, 1884, *i.e.*, before the Hewett Treaty had been concluded.

On the whole, therefore, the results of the Treaty and of Chermside's efforts were satisfactory. The heroic Gordon had met his fate in the fall of Khartoum on 26th January, 1885. The Mahdi died on 22nd June of that year and was succeeded by the Khalifa.* The British Government had ordered the withdrawal of all its expeditionary forces from the Soudan, and it became the task of the Egyptian forces to hold the frontier posts.

Chermside was transferred to command the troops at Wadi Halfa on the Nile, on October 20th, 1886. The Dervishes advanced to Gemai, 22 miles south of Wadi Halfa, on 13th October, and established themselves there under command of Nur-El-Kanzi.

Chermside countered this movement by a display of cavalry and camel corps, supported by an armoured train, and finally drove the invaders back, pushing into Sarras, some 32 miles from Wadi Halfa. Nur-El-Kanzi put in an appearance again on 27th April, 1887, and pushed on an advanced guard as before to Gemai.

Four hours after the news of this reached Chermside, he had pushed out a force directed on Sarras, and marching in the night, occupied the old railway station buildings and positions on the surrounding rocky hills with his mounted troops.

The infantry arrived by an early hour next morning and by 7.45 a.m. the enemy was routed all along the line, leaving some 200 dead on the ground and ten standards. This was a small action, doubtless, but the distance marched and the rapidity of the concentration which defeated the enemy within 14 hours of receipt of intelligence of his presence, call for especially favourable comment in view of this being the first occasion on which Egyptian troops confronted the Dervishes entirely independent of British or other support. The troops returned to Wadi Halfa and a period of tranquility ensued.

Chermside quitted Wadi Halfa some time in the summer of 1887, and terminated his service with the Egyptian Army in May, 1888, resuming his interrupted Consular duties: this time in Kurdistan, and thence returning in November, 1889, to Constantinople as Military Attaché. Here he spent nearly seven years. His activities during this period, of which no record is available, are doubtless locked up in the archives of the Foreign Office.

He was then transferred to Crete on the Commission for reorganization of the Cretan Gendarmerie, till March, 1897, and then British Military Commissioner in Crete and commanded the British troops on the island as Colonel on the Staff.

Expedition to Crete, September 24th to November 24th, 1898.—In order to realize the situation in Crete, the idea that the Cretan

* Abdulla Taashi.

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Mussulmans, or Bashi Bazooks as they are generally called, are Turks, must be abandoned. They do not understand either Turkish or Arabic. They, as well as the Christians, are Cretans and speak Greek only. Neither of them likes the Turk, nor does the Turk care for them. But in cases of dispute the Turk, naturally, sides with the Mussulman. The proportions are about one-third Mussulmans to two-thirds Christians: the former, therefore, depend on the Turk for protection.

The Mussulmans were farmers, while the Christians were traders. They had been assassinating one another since time immemorial and were about equal in savagery. On the whole, the pluck was on the side of the Bashis, but both preferred to murder without danger to themselves. The outbreak of about two or three years back, which led to the intervention of the Powers, was caused by Christians surrounding some 900 Mussulmans in a mosque and murdering the lot, after persuading them to surrender their arms on promises of their lives being spared. After this, in Kandia, the Christians were kept in the hills by a cordon of British troops, and the Mussulmans confined to within a few miles of the town by Turkish troops.

At the time mentioned, an outbreak had just occurred, resulting in the massacre by Bashi Bazooks of 600 Christians, including our Vice-Consul, the burning and sacking of the Christian quarter, and the killing and wounding of some British soldiers. The cause of this outbreak would appear to have been :–

(1) The Powers started interfering without making up their minds as to what result they wished to arrive at.

(2) When about to force on a town a tax, which they knew would be resented, they left on duty only one ship, the *Hazard*, which carried no weight of metal, while the remainder went off to coal, so that the weak British garrison of some 250 H.L.I. had to cope unassisted with some 20,000 well-armed Bashi Bazooks, in addition to some 4,000 Turkish troops.

Moreover, no measures were taken for entrenching under the specious plea that they would betray a lack of confidence.

When fire was opened from the loopholed houses, some of our unprotected troops were killed in the hospital tents and when playing football.

The International Council of Admirals at Canea had ordered all arms and ringleaders to be surrendered to the Turkish Governor, who was to hand them over to the British authorities. This was an order easy to issue but somewhat less easy to execute, and Sir Herbert Chermside, Major-General in Command of the troops in Kandia, which formed part of the Malta Command under General Sir Arthur Freemantle, Governor and C.-in-C., had a delicate task in hand to

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temporize until his Command had been reinforced by the arrival of some artillery and brought up to a strength of some four and a half battalions of British infantry.

In the end, the population was disarmed and the Turkish Governor and garrison coaxed by a judicious show of tact and force to embark in the transports sent to fetch them, and the incident closed for the while.

A Cretan police force was raised in various districts under British officers, and when Prince George of Greece arrived to assume command, Kandia was the only place in Crete where his safe conduct was entirely entrusted to Cretans.

It should be added that, when the massacre of the 600 Christians took place, Sir Herbert Chermside had just landed in England on leave. He was immediately sent for by Lord Salisbury and told to return and restore order. On arrival at Kandia, alone and unarmed, he walked up the Main Street, which was thickly lined on both sides by silent people, who only a few days before had been engaged in this outrage. The officer in local command greeted him with "Bey! If you had been here this would not have happened."

It may readily be grasped that Sir Herbert had a wonderful influence, by reason of an iron will regulated by a sense of justice and sympathy. This characteristic has, as is well known, a powerful effect on Orientals.

Crete to South Africa.—Proceeding home from Crete, he immediately assumed command of the troops at The Curragh. But he was moved in three months to take command at Aldershot of the 14th Brigade, 7th Division, in which he again spent only three months, during which time he took it out to South Africa, handed it over to General Tucker and succeeded Sir William Gatacre as the Lieutenant-General in Command of the 3rd Division. With this he served till early in 1901, resuming his old command at The Curragh.

His services in South Africa were not marked by any particularly prominent actions. He was not altogether fortunate in taking over a division that had borne the brunt of strenuous marching and harassing engagements of no decisive character. The units were constantly shifting, the Division frequently split up into separate detachments or strung out along the railway, holding the line.

He took part in the operations in 1900, in the Orange Free State, including those at Paardeberg, Poplar Grove, Karee Siding, and later, those in the Transvaal to east and west of Pretoria and in the Cape Colony.

On 3rd February, 1902, he was appointed Governor of Queensland and assumed office in March. Just before embarking for South Africa, Chermside had married Geraldine, daughter of Mr. W. Frederick Webb, of Newstead Abbey, who accompanied him to

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Queensland. Both Sir Herbert and Lady Chermside met with much cordial hospitality from the residents, and in their wide tours through the remoter parts of Queensland made warm friends all over the State.

He was not a man to stand on his dignity and he was approachable by all, regardless of station in life, and the fact that he was a good, all-round sportsman increased his popularity. He was not only a sportsman in the usual sense of the word, but he studied and knew the subjects of his sport, was a keen naturalist and a student of forestry and agriculture.

Above all things he abhorred unnecessary cruelty, and it is recorded that when invited to a grand pigeon-shooting match, organized in the Governor's honour, he declined to attend on discovering that the quarry were to be captive birds instead of clay pigeons.

He spoke his mind freely and yet did not detract from his own popularity thereby. In fact, the Colonists had an admiration for him as a man, as apart from his abilities as an able administrator.

It is to be regretted that he found it desirable to resign in September, 1904.

The Australian Parliament, in the interests of economy, had taken action with a view to reducing the emoluments and status of the State Governors. Chermside was desirous of resigning in June, but consented to remain on: but, recognizing the financial exigencies of the State, surrendered part of his emoluments.

Sir Herbert and Lady Chermside left Queensland, as he wrote to the Premier, Mr. Morgan, " with a very high interest and belief in its future and with the warmest appreciation of the kindness, friendliness and hospitality, nowhere to be surpassed, which we have invariably met with at the hands of all its citizens throughout our residence in the State."

More than once he received further offers of high posts from Lord Salisbury, who had a high appreciation of Sir Herbert's qualities: but he preferred to stick to the military profession which he loved.

Sir Herbert Chermside retired from the army in February, 1907, with the rank of Lieutenant-General, G.C.M.G. and C.B., and he was appointed Colonel Commandant R.E., in 1916. Lady Chermside died in 1910 and Sir Herbert spent the remaining years of his life in travelling and in developing his property.

He was greatly interested in forestry and fish culture and travelled much on the Continent, acquiring a great knowledge of these subjects, which he put to practical use in England. Farming also was his hobby and he was an authority on the making of pastures.

On 4th August, 1920, he married Clementina Maria, second daughter of the first Baron de Reuter, and widow of Count Otto Stenback.

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The writer was fortunate in renewing acquaintance with Sir Herbert and meeting Lady Chermside in the South of France. They were then travelling in search of new scenes, and rivers where Lady Chermside could display her prowess as an enthusiastic trout fisher. Failing health had for some years forbidden any form of such sport to Sir Herbert, but he was untiring in accompanying his companion to the waterside and participating as an onlooker in her sport.

There is little more to tell. Suffice to say he passed away at a nursing home in London on 24th September, 1929. Many details of rewards and decorations to be found in the usual books of reference have been left out.

The writer does not claim to present more than an outline of the remarkable career of a singularly unassuming man, whose association with the Corps was necessarily restricted by the nature of his service. And yet he may be deemed to have fulfilled the spirit of our motto.

Those who have had the patience to read so far and are desirous of probing more deeply into a fascinating subject, may find collateral evidence scattered in many publications, notable amongst which are :—

Mahdism and the Egyptian Soudan and *The Soudan Past and Present*, by General Sir F. Reginald Wingate, Bart., G.C.B., G.C.V.O., G.B.E., K.C.M.G., D.S.O.

Modern Egypt, by Lord Cromer.

Histories of the South African War. ("Official" and *The Times* editions.)

The Life of Major-General Sir Charles Wilson (late R.E.), by the late Sir Chas. M. Watson, R.E.

Apart from information contributed by our brother officers of the Corps we are indebted to others of the army at large and especially to :—

General Sir Reginald Wingate, Bart., G.C.B., etc.
General Sir H. M. Leslie Rundle, G.C.B., etc.
Colonel Lionel Fawkes
Mr. R. C. Corbett
} Late R.A.

Major-General Sir Francis Howard, K.C.B., late Rifle Brigade,

who have put their notes and memoirs unreservedly at our disposal.

J.A.F.

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MAJOR-GENERAL SIR S. ROBERT RICE, K.C.M.G., C.B

SPRING ROBERT RICE, the second son of Spring Rice, Esq., of Marlhill, Co. Tipperary, was born in July, 1858. He went to the "Shop" in 1875 and was appointed S.U.O., or as it was called then R.U.O. (Responsible U.O.) for his last term. He was one of the best riders in his term, and, passing out high (second or third), he was awarded the Sword of Honour, an appreciation of his military characteristics which was justified by his subsequent career. Even as a cadet he was a striking personality, strongly built, well set up, and extremely smart, with a courageous and rather masterful manner combined with excellent brains and much common sense. He was commissioned on the 9th of October, 1877.

While at Chatham he maintained his reputation for soldierly smartness and efficiency, while he entered with zest into all the recreations then available, became one of our best cricketers and footballers, and was frequently a member of the crew of the old *Dotterel*.

From Chatham he went to the 6th Company at the Curragh, and in 1881 was moved to Gibraltar, where he remained for about two years. He was a prominent rider to hounds at both these stations. In 1883, he went on to India.

On arrival there he was posted to the Bengal Sappers and Miners at Roorkee, and after three months was sent to Karachi as Assistant Engineer, Submarine Mining. It may seem strange that an officer with so strong a bent for soldiering should have gone "to the sea," especially from Roorkee, the great military centre of the R.E., but in the early days Submarine Mining was looked upon as the coming service, in which both scientific and practical training for war was to be obtained.

Rice threw himself wholeheartedly into this new work, and without any previous training in it became so efficient that in three years he was in sole charge of S.M. Defences at Karachi, and later on, on the death of Major C. C. Carter, the Inspector of S.M. Defence, India, he officiated in that capacity. To his keen disappointment, the vacancy was filled by an officer sent out from home, and Rice decided to leave India on the expiration of his first period of service.

He arrived home in 1889, and was posted as adjutant, S.M. Battalion, St. Mary's Barracks, where he resumed the military side of his R.E. duties with his customary energy.

The Mess was a cheery place, and Rice's humour and quick repartee, though caustic at times, kept things amusing. He now represented the Corps at football and cricket, and captained the latter team about 1890.

Having established his reputation as an adjutant, in 1892 he was

Major-General Sir S. Robert Rice, K.C.M.G., C.B.

Photograph by Bassano Ltd., 88, Dover Street, W.1.

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selected to fill the appointment of Adjutant, S.M.E., recently created by the reorganization of the Staff of the S.M.E.

In November, 1895, he took over the command of the 37th Field Company from Major A. H. Kenney, and in October, 1898, was transferred to the command of the 23rd Field Company *vice* Major A. C. Foley. One of the officers who served under him describes Rice's character in a nutshell. " He was a very good C.O. for a Y.O. to have. No excuse was ever taken " !

The Company was sent to Salisbury Plain in 1898, to prepare camps and arrange water supply for approximately sixty thousand troops. By Rice's directions, a separate project was prepared for each camp, in which every detail was meticulously included, and consequently everything went according to plan. This work was typical of the man. Given a job to do he would see it through to success, no matter what amount of labour was required from himself or his subordinates. When the manœuvres commenced, and water supply stores had to be taken up and moved on to successive camps, his orders on the subject were inflexible and no relaxation was made in favour of anyone, however high his rank, not excepting the I.G.F. himself ! At this period among his contemporaries who did not know him well he had the reputation of being idle. This, however, was due to a species of vanity with Rice. He affected to do nothing, but his subalterns knew that the projects for work and schemes for training, which were produced mainly by the pen of the Major, had involved the burning of many hours of midnight oil.

In June, 1899, the 23rd Company, which had moved from Aldershot to Chatham, was detailed to proceed to South Africa as one of the units included in reinforcements sent out as a precautionary measure. Rice proceeded with his company to Ladysmith, and was there throughout the siege.

It is a singular fact, but the Staff of that day did not consider that a C.R.E. was necessary for a besieged town. Rice, although the senior R.E. officer doing regimental work, was never regarded as more than the O.C. of the Field Company, and he was rarely consulted on the all-important subject of defence works.

The defences of Ladysmith were designed and made by the Commander of each section of defence, as seemed best to him. On one occasion, the holding of Wagon Hill was a matter of discussion at a conference at which Rice happened to be present. Ian Hamilton, the commander of the section, recommended holding the rear crest. Rice pressed very strongly that the forward crest should be held, and Sir A. Hunter, the Chief of Staff, agreed with him. Sir George White, however, decided that the commander of the section who was responsible for the defence should hold it as he thought best. The sequel showed that Rice was right. On the morning of the battle, he had gone out to Wagon Hill early to find out what was going on, and was on his way back to make arrangements for further help for

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the R.E. when he met Ian Hamilton, who asked him what had happened. Rice told him and gave the reason.

An officer of the Staff of Sir George White says that the only time he saw Rice otherwise than calm and unrattled during the whole of the siege was when he came in to H.Q. on the evening of the Battle of Wagon Hill to report the gallant services rendered by the R.E., and announced with tears in his eyes that his two subalterns, Digby Jones and Denniss, had been killed.

Another episode of the siege in which the 23rd Company were involved was the raid on Surprise Hill. This was suddenly arranged by the H.Q. Staff. About 6 p.m. Captain Fowke, 23rd Field Company, R.E., was called to H.Q. and informed that he was to go with the raiding party and blow up the Boer guns. He, of course, went to Rice and told him what had happened. Rice, who had every right to be annoyed at this cavalier treatment, was, however, quite unruffled, and made everything as easy as he could for his Captain by selecting the best N.C.O.s and men for the job and arranging the issue of the necessary equipment from the Company stores.

On the relief of Ladysmith and the subsequent advance by Buller's Army into the Transvaal, Rice became C.R.E., 4th (Lyttleton's) Division, and eventually the Company settled down at Middelberg, Transvaal, where Rice was C.R.E. and the Company did the ordinary Field Company job of defences, water supply, quarters and provision of parties of R.E. to accompany mobile columns.

Early in 1901, Fowke had been asked to provide a raised platform, so that some signallers should be able to cover some dead ground. This was done, and, soon after, another request was received to put some protection round the platform, for the signallers were being sniped. Fowke then put up some sheets of corrugated iron with stones between, and this was found to give complete protection.

As time went on, the Boers turned their attention to the railway communications, and this necessitated the multiplication of defence posts along them: from this developed the system of blockhouse defence, for it was quickly found that defence by means of open works was only asking for trouble.

To meet the case at certain important river crossings, the Engineer-in-Chief had had designs prepared of blockhouses, of the nature of miniature Norman castles, for distribution to the various C.R.E.s. Rice, as C.R.E., Middelberg, received these designs, but saw at once that they were not of general application, as they cost about £600 each, and took about six weeks to build. While Rice and Fowke were thinking over the subject, Rice suddenly said, "Why not try your defence for signallers?" and then they both sat down to work out details. From this moment the corrugated iron blockhouse had come to stay. It was at first octagonal in shape, but gradually it assumed the design which is now familiar in our text-book—the circular shield, roofed, and resting on a parapet of earth or stone.

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The H.Q. of the 23rd Company under Rice's direction now became a standardized blockhouse factory, the materials passing through successive stages to completion with astonishing rapidity and absolute accuracy.

The development was reported to Lord Kitchener, who immediately grasped the supreme importance of this new weapon now ready to his hand. He at once gave the order for the construction of the first cross-country blockhouse line ; this was followed by orders for others in quick succession, until the Transvaal and Orange River Colony were divided up into defined areas. The mobility of the Boer Commandos was severely hampered, for even if the blockhouse lines did not always stop them, the break-through invariably gave valuable information as to their movements, and probable direction, and the drives by our mobile columns became the irresistible realities which ended the war.

The invention, in itself so simple, was exactly what the situation required for a country like South Africa, with its wide open spaces of rolling veldt. The made-up material was easily portable on the transport wagon of the country ; the material required locally, earth or stone, was nearly always available on the site, and the protection afforded against bullets, rain, and sun was complete.

If unbiased evidence is required as to the part the blockhouse played in ending the war, it will be found in books written by Christian de Wet* and Reitz.†

It had been suggested that the blockhouse in South Africa, though stationary, played a part in ending that war comparable to the part played by the tanks in the Great War. That may be so, but the reward obtained was very different. For his services in South Africa Rice was mentioned four times, and received a brevet lieut.-colonelcy, which gave him a bare six months' seniority as lieut.-colonel.

His brother officers and personal friends, who knew what he had done and how much had resulted from it, thought that he had been hardly treated, but he himself, though grievously disappointed, never grumbled or even spoke about it.

Almost his final act before leaving South Africa was to put forward a design for the benefit of the Transvaal Government, showing how two blockhouses could be combined into one residence named " Peaceful Villa."

He came home in August, 1902, and shortly after married Mary Dalrymple, widow of Henry Scaunell, late Inspector General of Police in Bombay, and daughter of the late Major George Dancer, R.A. With the greater happiness which came into his life he lost much of his official austerity.

He was posted first to Cork as D.O., then to Fermoy as C.R.E., then to Portsea, where he completed five years as Lieut.-Colonel.

* *Three Years' War*, by C. R. de Wet. † *Commandos*, by Denys Reitz.

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He was promoted Brevet Colonel in February, 1906, but this did not save him from a year of half-pay.

In September, 1909, he was appointed Chief Engineer, South Coast Defences, and was there able to carry out many schemes he had in mind for strengthening the fortress defence of a place by supplementary earthworks.

After two years, he was posted to Aldershot in succession to Scott-Moncrieff, who went to the War Office as D.F.W. Here Rice came under an old South African friend as C.-in-C., Sir Douglas Haig, who knew him well, and who left, with complete and well-deserved confidence, all engineering matters entirely in his hands. He took great interest in the fieldwork schemes of the Field Companies, and by his help they were enabled to carry out exercises in making full-sized defence posts, *points d'appui*, as they were termed in the text-book, teaching which was to have far-reaching effect in the Great War.

On the outbreak of war in 1914, he went to France as C.E., 1st Corps. During the first hundred days there was little scope for a Chief Engineer where work was all of a temporary nature, and troops moved so rapidly that it was impossible to organize any system for the supply of engineer stores, or tools. He was used by Sir Douglas Haig as an extra Staff Officer for liaison, reconnaisance, and reports when these were of special urgency or importance. These missions he performed with such good judgment, and the information he obtained was generally so essential that Haig soon learnt to regard him as one of his best agents.

On one occasion an amusing incident happened, which he was fond of telling. He had to visit a French reserve battalion, who were making a defensive post at the bridge of Guise, and not being satisfied with the design he summoned up his best French and suggested some improvements to the French officer in charge. Rice was not a good French scholar. Much to his amazement the officer replied in perfect English, " I entirely agree with you, sir, but what the devil can I do with these blighters ? " After some further conversation he discovered that the officer was the French master at a well-known English public school.

As an instance of his ability to appreciate a situation, it is on record that in September, 1914, he stated in the Mess to which he belonged that in his opinion the war would shortly develop into trench warfare and that there would be a condition of stalemate for at least a year. This statement was accepted by no other member of the Mess at the time, but events proved that he was perfectly correct.

During the first Ypres, he was sent to a divisional headquarters with certain orders on which depended the fortunes of the day. His ability to appreciate the true facts of the situation enabled him to make a vital decision on the course of action to be followed, which was completely successful, and of which Haig entirely approved.

During the early days of the first Ypres, he was instrumental in

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putting into practice the construction of strong points (*points d'appui*) in the support lines. Several of these were on the front attacked by the Prussian Guard on the 11th of November, and by their agency the assault was broken up and smashed.

This system of strong points interposed amid the trench system always formed part of any scheme of defence for which Rice was responsible. On the creation of the First Army he became C.E., First Army, and was gazetted Major-General as a reward for services in the Field.

Later, it was decided to form a Field Force at Salonika, and he was sent there to take over the duties of Chief Engineer, but when General Fowke was made Adjutant-General in France in March, 1916, Rice was ordered back to France to replace him as Engineer-in-Chief, where he remained till November, 1917.

On his arrival in France, the preparations for the Battle of the Somme were in full swing. He found that his functions as E.-in-C. touched nearly every branch of engineering; the growth of the armies in France, together with the experience gained in the changing form of warfare, resulted in demands for greater numbers of engineer units of an ever-increasing variety, and it was in Rice's time that these additions were fully developed. This brood of new units has been immortalized in the well-known cartoon "War-Babies."

The scrutiny of these demands and their final recommendation rested with the E.-in-C., and his old friendly relations with Haig, to whom he had frequent direct access, did much to secure his favourable consideration and final approval. It was this same old friendship which enabled him to press on Haig the eligibility of C.R.E.s of divisions for the appointments of the command of infantry battalions and brigades, which was eventually approved.

The distribution of all kinds of engineering stores was to a large extent controlled in his office, especially those it was necessary to ration. Until the creation of a Directorate of Roads after the Somme, all roadwork in the Army areas was administered by the French *Commission d'Armée du réseau routier*, on which Rice's Staff was represented.

Plank roads, which were first adopted during the Somme, and then became of universal application, involved the supply of enormous quantities of timber.

The design and provision of road bridges of various types were worked out and organized for the general advance which was always confidently anticipated in his office, and, when Rice left France in 1917, no less than three and a half miles of bridging were already in the engineer parks.

In 1916, a school of instruction was opened at Aire, at which classes of selected officers were practised in handling each type of bridge, and this teaching contributed largely to the marked rapidity which was an outstanding feature of all bridging operations of 1918. Special equipment for water supply was also designed and provided.

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The success of the mining organization, which culminated at the battle of Messines, was built up during Rice's regime.

Camouflage, a new science, was developed from its original type of individual observation posts, machine-gun nests, etc., disguised as trees, kilometre stones, or heaps of road metal, etc., to the wholesale screening of roads, battery positions, camps and dumps, against aerial observation and was provided with its own factories for supplying its special material.

Geology, an old science, but one hitherto somewhat neglected as far as field operations were concerned, now found a wider scope in the E.-in-C.'s office. Hutting for placing enormous numbers of men under suitable cover was provided from designs evolved under the direction of his staff. Besides these, there were many other forms of engineering problems dealt with under him, which can only be mentioned generally.

As Engineer-in-Chief, one of his Staff says: "His ability and common sense were undoubted. He had a deep antipathy to any personality tinged with self-advertisement, jumpiness or fuss. He expected a high standard of efficiency from all his officers, and was not disposed to bestow praise for what he considered should be the natural maintenance of that standard; nor did he think that such would be due to himself. His natural reserve and personal detachment, blended with a peculiar form of shyness, prevented intimate relations either with his own Staff or with that of the Armies; but when he had gained confidence in any of his officers, he left them an absolutely free hand, contenting himself with general supervision and advice, and unfailing support of their efforts. He was a very good judge of men."

In November, 1917, the C.-in-C. decided that Rice, with other senior and distinguished R.E. officers, whose average age was naturally somewhat higher than that of the remainder of the officers on the Staff, had been sufficiently tried by the storm and stress of three years' war, and was now entitled to a tour of home service, where the conditions might be less trying. This enforced rest was none of Rice's seeking, as may be imagined. He was appointed to the command of the Forth Garrison at Edinburgh, and held that post until he retired in 1919.

For his services during the War, he was mentioned in dispatches six times, promoted Major-General, K.C.M.G., C.B., and received from our Allies the Cross of a Commander of the Order of Leopold (Belgium) and the Croix de Guerre (France).

Like so many of our older officers, the strain of war had affected him more than was realized, and he did not live long to enjoy the peace he had helped to bring about, for death suddenly claimed him at his residence in Brighton on the 11th August, 1929.

R.N.H.

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BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

CHANGING CONDITIONS OF IMPERIAL DEFENCE.

By CAPTAIN D. H. COLE, M.B.E.

(Sifton Praed. Price 6s. 6d.)

This admirable little book, by the author of the standard work on imperial military geography, will appeal strongly not only to those whose calling necessitates a study of the problems of imperial defence, but will also be welcomed by the many others who still regard the British Empire as a living reality in spite of necessary changes in its nomenclature, composition and inter-relationships, and unnecessary attempts to prove that Empire and domination by Great Britain are synonymous.

On the other hand, whole-hogging pacifists will find little encouragement in the following comments on recent attempts to abolish war by covenant :—

" In fact, the advice, ' Don't think of war and don't prepare for war, " and there will be no war,' is highly idealistic. ' Don't think of burglary, " don't prepare for burglary, and there will be no burglary ; have " lawyers, well codified laws, commodious and well-appointed courts, " but no policemen,' is not an unfair parallel.

" The British Commonwealth of Nations is perhaps the greatest " peace-making force in the world to-day, because its interests are so " widely dispersed that it is liable to lose either as a combatant or a " neutral. But it can only exercise its capacity for peace to the full by " being strong in war if necessity should arise."

As explained in the preface, the book does not pretend to contain full discussions of the important subjects and controversies to which its pages refer. The writer's aim has been to present briefly and clearly some of the more important of the changing conditions which affect imperial defence and imperial solidarity, and as far as possible to give an unprejudiced account of those problems of the other great naval powers which may have reactions on our own position.

In view of the recent London Naval Conference, the book is of particular interest at the present time, and sheds considerable light on the difficulties to be faced in any attempt by the great naval powers to reduce their armaments.

The author starts from the basis that national defence is dependent on man-power in association with material resources and power of

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movement, and analyses the present and possible future situations regarding these factors. In connection with man-power, he points out that since two-thirds of the white population of the Empire, which is the foundation of the structure of imperial defence, is now situated in Great Britain, the necessity for organization to achieve unity of thought and action throughout the whole Commonwealth has not yet reached a vital phase. In another half-century, however, the population of each of the Dominions is likely to have doubled, while that of Great Britain, he estimates, will never exceed 60 millions. In 60 years the bulk of the white man-power may well be outside Great Britain. Is the minority then to bear the larger part of the burden of defence? If not, how must our defence organization be modified?

The chapter on the material resources of the Empire shows clearly the dependence of Great Britain for food, and for most of the raw materials used in industry, on overseas supplies, and the dependence of the Empire as a whole on foreign sources for a number of vital commodities, the chief of which are cotton and petroleum.

These weaknesses are, as the author points out, shared in varying and increasing degrees by all the industrial powers, who do not, however, possess to any corresponding degree the strength accruing to the British Empire from our control of a number of essential commodities, our ownership of 35 per cent. of the steam and motor ship tonnage of the world, our financial situation, and our predominance in the coal bunkering trade.

Our general material situation necessitates sea power and control of shipping, and "A nation with a world-wide sea trade and a great tonnage "of shipping, but without a navy capable of defending it would be "living in a condition of dependence on the goodwill of others, a "dangerous habit, even when guaranteed by pacts and treaties."

The chapter devoted to the "United States and Sea Power," bristles with interesting information and conclusions. The author demonstrates the growing dependence of the United States, owing to rapid industrialization and the growth of population, on markets abroad, and on imported raw materials for her factories. "This dependence, as it "increases, will be accompanied by a corresponding necessity for the "security of her lines of sea communication to every part of the world. "In this respect her interests will be similar to those of the British Empire—the absolute security of her sea-borne trade."

The respective attitudes of Great Britain and the United States with regard to "the freedom of the seas" are well summed up in the words of an American. "When the British Government is neutral it tends "to act the way the Americans talk: when the American Government "is a belligerent it acts the way the British talk."

France and Italy in the Mediterranean, Great Britain and the Indian Ocean, and Japan and the Pacific, are in turn dealt with by Captain Cole, whose aim is to show that "we must remain a great sea power or perish."

Finally, he comes to one of the greatest problems of the future: How is the world's growing demand for food to be met?

"The population of the world increased from about 500 millions in "the year A.D. 1700 to 600 millions in the year 1800 . . . by 1850 the

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" population had reached 1,000 millions. To-day it is over 1,800 " millions, and it is increasing at the rate of over 15,000,000 a year. " Needless to say, the acreage available for food production cannot be " extended indefinitely. The best lands are already under cultivation " —the remainder of the potentially arable land is mostly poor and " unlikely to produce crops comparable with those now produced. . . . " Where are the lands which can be developed to meet the world's " growing demand for food? . . . Much of the available area is British " and much of it belongs to British Dominions weak at present in " population. These areas must become increasingly desirable to other " countries with much larger and denser populations."

" Does the British Empire present a united front towards these " dangers which may not be so very remote? "

The author's conclusion is that while peace pacts and covenants have undoubted value, they must inevitably contain loopholes, and that the British Commonwealth of Nations can only exercise its great capacity for peace to the full " by being strong in war if the necessity should " arise."

The shrinking of the world due to improved communications, while it helps, does not necessarily solve our difficult problems arising from dispersion. The real foundation of imperial defence must, in the author's words, be " the maintenance of a proper team spirit " which might well, he suggests, be based on (1) the development of common interests in trade, (2) the development of constitutional machinery for maintaining a continuous common policy in foreign affairs, which would be able to function without delay in a crisis, (3) the assurance that the governments of the Empire would be prepared to enforce this common policy, and (4) a sharing of the burden of naval and air defence based on the amount of overseas trade which each country possesses.

The continued existence or, alternatively, the disruption of the Empire may well depend on the manner in which this " team spirit " is fostered.

It is to be hoped that this book will be widely read both in Great Britain and in the Dominions, not only by the military student but by budding statesmen and the " man in the street," whose collective vote in these democratic days is, in the last resort, the determining factor in the constitutional evolution of the Empire.

G.N.M.

SHERMAN—THE GENIUS OF THE CIVIL WAR.

By B. H. Liddell Hart.

(Benn. Price 21s. net.)

Captain Liddell Hart is back from another lion hunt in the obscure fastnesses of military history. Recently he produced a fine specimen, Scipio Africanus, " a greater than Napoleon." Now it is Sherman —" the genius of the Civil War." The hunter has measured his kill with the elastic tape of the " indirect approach " and the result is here announced to the military world.

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This is very confusing to the simple soul of the orthodox soldier who has heard a lot about Jackson, something about Lee and vaguely of Grant. To find the truth, we must read and re-read the great masters. General Sir Frederick Maurice has but recently proved Lee to be the genius of the Civil War. Brigadier Fuller is about to prove that Grant was the genius of the Civil War. Captain Liddell Hart will have to fall-in his genius alongside the others. To the orthodox observer, it would appear that it took the combined efforts of Genius Grant and Genius Sherman to put it across Genius Lee, and of the three, Lee had been registering authentic genius for some two years before Grant and Sherman became serious challengers.

Still, it is no use quarrelling with the wrapper or the title page. The rest of the book is excellent. The writer sets out to produce a picture of Sherman, the human being, and he does so—" not merely of a man's " limbs and muscles encased in uniform clothing." Sometimes the portrait is a little blurred as the shadow of the photographer falls across the photographed. Occasionally the writer's image obscures Sherman's. But Sherman always reappears, and the writer is at his best when he quotes Sherman's actual words, as he does frequently and appositely.

We first see Sherman, somewhat submerged under " demerits," at West Point. The writer disapproves of military academies and makes an unfair use of passing-out lists from such places in deducing the military characters of general officers. We see Sherman as a young officer—keen, observant, impetuous. We see Sherman in the hopeless 'thirties, that period of military doldrums in which the best of soldiers, Lord Haig among others, become morally becalmed before reviving to fresh activities in the roaring 'forties. Then Sherman the civilian—an indifferently successful business man—perhaps hindered by his early overscrupulous upbringing at West Point—and lastly, Sherman back to the army—or as near as he can get to it—conducting an embryo military academy in the South. There the war finds him.

Sherman's reaction to the War is interestingly told, though the author, in the chapter heading, perpetrates a ghastly pun, when he writes of a " Realist in Wonderland " (this is not the sole offence, elsewhere we read that " the Tocsin of War was a toxin in the blood "). There is Sherman at Bull's Run—Sherman holding Kentucky for the Union, half-crazed by the incompetence at Washington and very close to psycho-neurosis. Sherman baited by and baiting war correspondents (orthodox soldiers, take heed how you treat the journalist and note that nothing is better for an army in the field than paternal criticism of its commanders by an enlightened press) and Sherman as a divisional and Corps Commander settling down to warfare in the Mississippi Valley.

We are shown the beginning of the Sherman–Grant friendship during Grant's bowler-hatted obscurity after Shiloh, and we see the fateful combination maturing during Grant's all-round-my-hat cast after the Confederate fox at Vicksburg.

Then there is Chattanooga and at last, in 1864, Sherman commands in the South the Right Wing of the Federal Armies, at the age of 44.

When Sherman assumed independent command, the War had taught him three things of which the writer approves. Firstly, the value of

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mobility and the measure of "Q"; secondly, the advantages to be gained by operating on the widest possible front compatible with control and mutual support of the separated parts of his force; thirdly, the futility of direct attacks against an entrenched enemy unless that enemy is off his balance, and the wastefulness of holding ground gained for ground's sake. These added to his restless energy—which in less exacting times was damned as impetuosity—are sufficient, in a theatre of war where all is flank, to carry him 130 miles from Chattanooga to Atlanta in a dignified gavotte with the Confederate Army. There, the dance over, he somewhat puckishly pulls the stool from under his partner, the Confederate General Johnston, who comes ungummed in every sense.

Finally, during a further military Paul Jones, Sherman, more ungallantly unorthodox than ever, leaves the Chattanooga–Atlanta Ball Room and his Confederate partners and enemies, and Charlestons off to the sea *via* the Confederate Supper Room, where he takes what he needs and destroys what he leaves. This rudeness ends the dance. It is, however, questionable whether Sherman could have pulled it off had not Grant been somewhat importunately buttonholing Lee, the Confederate Chucker-Out. In any case, the responsibility was Grant's —Grant created the opportunity—the truth is Grant and Sherman understood each other and Lincoln had learned to trust the combination. In addition, the South was losing hope—Federal combination produced Confederate collapse.

The last two chapters and the epilogue are exceptionally good reading. Whatever be Sherman's merits in comparison with other American commanders of that War, one is left with the memory of a broad-minded, far-seeing professional soldier—hard yet merciful—a great enemy to misplaced sentiment and to humbug. His outstanding military qualities are his loyalty to his subordinates and his power of getting the maximum out of his administrative organization, his topographical staff and his engineers, and by so doing conserving the energy of his fighting men.

On some occasions in the text, and always with the maps, the author has let his penchant for the "indirect approach" overstep its proper application. Too many sentences start from an "If" and vanish into a fog of parentheses before they emerge with the real meaning, and the maps are always placed at the beginning of the period to which they refer and are not available when wanted.

These, however, are minor defects in a work which embodies much research and which is a valuable contribution to military knowledge of the Civil War, and is equally valuable as a stereoscope through which the Great War may be examined in clear relief.

Moreover, peace, too, comes in for inspection—"War is a symptom of a diseased peace," is one of the writer's many good sayings. He might have added that we have no X-Ray apparatus with which to inspect how far gone in disease our peace may be. Indirectly, this book is a reflection on disarmament and Kellogg Pacts. Nothing was ever less likely than the Civil War. Nothing was ever more inevitable once the politician had really begun to prevent it. That war having been, any war is possible.

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It is claimed that Sherman was the typical American. The writer records a youthful statement of that typical American: "For my part, there is no nation that I would prefer being at variance with than the British."

How unthinkable!

E.D.-S.

INDIA UNDER WELLESLEY.

By P. E. ROBERTS.

(G. Bell & Sons. 15s. net.)

The Marquis Wellesley was Governor-General of India between 1798 and 1805. At that time, control of our Indian interests at home was divided between two authorities, the Court of Directors and the Board of Control. The responsibility of the two and their position as regards the Governor-General were ill-defined and overlapped to a certain extent, and their orders were sometimes conflicting. Wellesley, therefore, like a wise man, did what he thought to be right.

When he reached India, the British Empire there was very much in extent as Warren Hastings had left it thirteen years before, for Pitt's India Act committed us to a policy of non-intervention. He left it after Mysore, our most serious rival in the South, had been crushed, the Mahratta Confederacy defeated, and the British unquestionably acknowledged as the paramount power in India.

The causes which led Wellesley to embark on this scheme of aggrandizement were two-fold: firstly, as a counterfoil to French intrigue; and secondly, a genuine feeling that the *pax Britannica* was preferable to native misrule.

As regards the first, the author is careful to point out that the seven years of Wellesley's administration coincided with the darkest period of the French wars; when our naval supremacy was not yet undisputed, and there was a certain danger of invasion at home; when our military expeditions were of the "tip-and-run" order, and our Continental allies were, one after the other, collapsing before the French armies. The French were at Mauritius and the Seychelles, and, by their conquest of Holland, dominant at Java. They were in correspondence with Tippu of Mysore; French officers were training the armies of the Nizam at Hyderabad and of the Peshwa at Poona; and French adventurers were carving out kingdoms for themselves in Hindustan. The memory of Dupleix was still alive, and although Napoleon's scheme of marching a French army overland to India is generally dismissed as chimerical, a Perso-Afghan force, with French backing, might have caused us considerable trouble: it was only sixty years since Nadir Shah of Persia had sacked Delhi. Small wonder, therefore, that Wellesley considered attack to be the best defence.

As regards the second point, it is unquestioned that there was misrule under native rulers, such as amply justified British intervention; but we would prefer, from such an able pen as that of Mr. Roberts, something more than mere reiteration of Wellesley's statements to that effect. He does, it is true, give us a few hints as to how things were managed in

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Indian states; for instance, that the Mahrattas collected revenue from subjugated districts by levying *chauth*, a word meaning a quarter. But something more vigorous is required in the way of propaganda if educated Indians are to realize "the rock whence they were hewn and the hole of the pit whence they were digged." Holkar, for instance, on capturing Poona in 1802, had his unfortunate rival tied to the leg of an elephant, and dragged through the streets of Poona till he was dead; nor was this regarded at the time as anything out of the ordinary in the way of disposing of political prisoners.

The wars waged during Wellesley's administration, that with Mysore, in 1799, and that with the Mahratta Confederacy, in 1803–05, were admirable examples of the co-ordination of forces acting from widely separated bases, for the success of which Wellesley himself, though he did not take the field, must receive a great deal of the credit. In both, Wellesley's brother Arthur, the future Duke of Wellington, took an important part. Nor must we forget the dispatch of a British–Indian force to Egypt, which, says the author, proved that the far-off Indian Empire was able to react on the European situation. The Mahratta War was marred in its later stages by two regrettable incidents, Monson's retreat and Lake's failure to storm Bhartpur, mishaps which drew the censure of the authorities at home, and so caused Wellesley to resign.

Wellesley's policy, where Indian states were concerned, was undoubtedly high-handed, judged even by the standard of 130 years ago; while his custom of acting first and reporting afterwards was not always justified by the distance between him and his superiors at home. But, in spite of faults, he was one of the greatest of Indian rulers, and a later generation, fortunately during his lifetime, was able to see things in a truer perspective and to know that, "in his own peculiar sphere and in his destined hour, a great ruler of men had walked in their midst."

Considered as a biography, the book may quite fairly be described as a model; for the author neither magnifies the virtues nor minimizes the faults of his hero. Throughout, we have the feeling that Wellesley's failings are being tried by an absolutely impartial judge; and that his merits are receiving their perfectly just appraisement. And not only so, but previous writers on India and Wellesley receive what we cannot fail to feel is perfectly fair treatment. May we hope that Mr. Roberts will use his remarkable talents in further work of the same kind?

F.C.M.

RACKETS IN INDIA.

By Colonel A. R. Winsloe, C.M.G., D.S.O., with a Foreword by Major-General S. H. Sheppard. C.B., C.M.G., D.S.O.

(Bennett Coleman & Co., Ltd. Price 7s. 6d.)

The author, in his Preface, says the object of his book is to show the rackets player where he may get his game in India, and how to get it cheaply, and he has certainly succeeded. After a short history of the game in India, and a note as to the chief players, come the laws with some apt comments on them. Two very useful chapters follow on how

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to get and keep balls and rackets. A list of the courts in India is then given. The final chapter gives a short account of the formation and objects of the Indian Rackets Association, which owes its inception to the author and which has already done much to cheapen the game in India.

Lists of all competitions held, with the previous winners, specifications for coverings of walls and floor and for a door to rackets courts and hints on stringing and repairs to rackets are contained in appendixes.

All officers ordered to India would do well to buy a copy of the book, even if they do not play rackets, as the hints on the keeping of rackets apply also to tennis and squash.

B.L.E.

THE CAVALRY WENT THROUGH.

By BERNARD NEWMAN.

(Gollancz. 7s. 6d. net.)

This is a war novel; not an account of unsavoury personal experience but a pure flight of imagination. It portrays "the War as it might have been," had the "Napoleon" arisen whose appearance we gave up expecting. In France arrives Colonel Duncan with his ragged battalion of supermen, with which he had beaten the Germans in German N.E. Africa, in a brilliant campaign. In spite of the unconventionality of the whole outfit, their fighting qualities are soon recognized, and the Iron Battalion grows to the Iron Brigade, and the Iron Brigade to the Iron Division, commanded by Duncan. The exploits of the Free Companies behind the German lines, the pinching-out of the St. Mihiel Salient, the capture of the Gallipoli Peninsula and the consequent fall of Constantinople are all told in capital style. Duncan, of course, becomes British Commander-in-Chief and Generalissimo of the Allied Forces, and the War ends in 1917. As the wrapper has it, "Here, we take leave to say, is a perfectly gorgeous 'stunt.'"

P.H.K.

NOTES ON AIR SURVEY IN INDIA.

(*Professional Paper No.* 24.)

By MAJOR W. J. NORMAN, M.C., R.E.

(Published by order of Brigadier R. H. Thomas, D.S.O., Surveyor-General of India. 1929. Price 2s. 6d.)

These notes are a review of past and present methods, and of work carried out in India during the period 1924–28. They have been written, as stated in the Foreword, for the use of officers of the Survey of India, who have had little practical experience of air survey and have not had time to study the literature on the subject. We think that the

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author has, on the whole, well carried out the task which he has set himself.

A very good summary is given of the points which have to be attended to in considering an air survey project.

A section is devoted to the theory and geometry of air survey in which the various conditions under which the air photograph may be taken are treated, such as distortion due to ground relief and to tilt of the camera.

Another section is devoted to an account of the method of plotting and compilation from photographs. A short description is also given of the instruments employed in aerial survey.

The last section of the notes gives a summarized account of the work done in India during the last five years. This work appears to have varied from 3-inch scale for forest maps to 16 inches to the mile for settlement purposes.

Numerous references are given to various publications which have appeared during the last few years, where full details can be found of the different methods touched on in these notes. There are a set of very clear diagrams illustrating the text; they are printed so as to open clear of the text, a practice which is always appreciated by the reader.

H.L.C.

THE SEREOGRAPHIC SURVEY OF THE SHAKSGAM.

By MAJOR K. MASON, M.C., R.E., Survey of India.

AN ATTEMPT TO DESCRIBE MR. WILD'S SEREO-PLOTTING MACHINE—THE AUTOGRAPH.

By ARTHUR HINKS, C.B.E., F.R.S., (Secretary, R.G.S.)

(*Technical Paper No. 272.*)

(Issued by the Railway Board, Simla. Price 2s. 3d.)

This appears to be a reprint from the *Geographical Journal* of a paper read by Major Mason before the Royal Geographical Society, in May, 1927. To this has been added an account of the geometry of the Wild autograph, which is not at all easy to understand, unless taken in hand by such a lucid exponent as Mr. Hinks.

He who desires to master the details of this complicated instrument is recommended to read this attempt to explain it. He will have to assist him numerous photographs and diagrams, as well as a mathematical disquisition.

Since this paper is published by the Indian Railway Board, we presume they are of opinion that the method could be applied to railway survey, which, we think, it could in certain classes of country, and we believe it is being used in connection with a Turkish railway project in Asia Minor. It is, therefore, worthy of the attention of railway engineers.

The apparatus, however, is very expensive, running into several thousands of pounds, and we fancy would require a very skilled operator to work it.

H.L.C.

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CONCRETE CONSTRUCTION MADE EASY.

By TURNER and LAKEMAN.

(Published by Concrete Publications, Ltd., 20, Dartmouth Street, Westminster, S.W.1. Price 3s. 6d.)

The authors have written this book, primarily, for the use of engineers, architects, contractors and builders who have concrete building work to carry out for which no plans are available.

Secondly, to help young engineering students who are starting to learn the methods by which reinforced concrete structures are designed and constructed.

Chapter XI (General Specification and Notes), which the authors recommend should be read first and yet have placed at the end of the book, contains a great deal of information, very useful to anyone who has to make out specifications for a reinforced concrete job, which is not easily found in text-books on the subject.

It also contains data which every young engineering student should know before he takes part in the design or construction of any job in the field.

In the chapters on design and construction, the authors have dealt with footings, columns, beams, lintels, floor and roof slabs, panel walls, staircases, saw-tooth roofs, water tanks and retaining walls.

The designs given are sound for the conditions of loading assumed, but are inclined to be wasteful in the use of material.

The figures and diagrams given show the methods of placing the reinforcement in the various structures dealt with, and are designed according to the recommendations of the recognized text-books on the subject. They are clear and would be useful to anyone with a reinforced concrete job to design.

The examples given, which show how shuttering should be designed and fixed, are good, and emphasize the importance of economy in the use of materials.

To sum up, the book would be of value to anyone who has a sound knowledge of concrete design and construction and who is required to build a structure to carry the loadings, etc., as assumed by the authors.

In the hands of a young engineering or other student, it is thought that the book might have a dangerous tendency to make him believe that he could treat a complicated subject lightly.

B.C.T.F.

MODERN FRAMED STRUCTURES.

PART II.

STATICALLY INDETERMINATE STRUCTURES AND SECONDARY STRESSES. By the late J. B. JOHNSON, C.E., C. W. BRYAN, C.E., M.A., and F. E. TURNEAURE, DR.ENG.

(Chapman & Hall, Ltd. Price 25s.)

This part, of which the first edition appeared in 1910, has been re-written and consists of eight chapters, of which the contents of only the last three are adequately covered by the title.

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Four chapters (Chapters II to V) are devoted to the calculations involved in the design of bridges of the swing, cantilever, arch and suspension types, a number of which are statically determinate.

The remaining chapter (Chapter I) is of an introductory nature and has apparently been considerably amplified in this edition.

It is unfortunate that the Macaulay method is not included in this chapter for comparison with algebraic, graphical and semi-graphical methods of analysis applicable to the many constructional problems involving the deflection of beams.

The use of the area moment method is, however, particularly clearly demonstrated, and the importance in truss design of the consideration of deflection, due to shear stresses in the members, is emphasized.

The treatment of the various types of bridges in the ensuing chapters is logical and relatively complete, although the space allotted to cantilever bridges is comparatively small, while that referring to suspension bridges has been considerably reduced in this volume, major attention being paid to those of the stiffened types.

The recapitulation in Chapter VI of matter already detailed in Part I is, perhaps, over-condensed, but the sections on trussed beams and beams on multiple elastic supports are really good.

An interesting comparison is afforded in Chapters VII and VIII between Winkler's and Mohr's methods of secondary stress analysis as applied to a Platt truss. The example is fully worked out by both methods and it is shown that in the formulation and solution of the equations of equilibrium of the joints, the advantage lies with Mohr, as permitting a more practical use of rapid approximation.

The subsequent process of solution for moments is, however, more readily carried out by Professor Winkler's method.

There seems, therefore, to be little to choose between them, although the authors appear to be of the opinion that, for beginners, the use of the Mohr method is more advantageous.

It cannot be said that the book is one which every sapper officer should possess, but it would undoubtedly be of value for reference purposes to officers involved in precise design work.

Attractively produced and profusely illustrated, the book is eminently readable and relatively self-contained; it is, however, regrettable that there are so many misprints, those on pp. 202, 367 and 393 being particularly unfortunate.

A.D.C.

(1) THE PHYSICAL PRINCIPLES OF WIRELESS.
By J. A. RATCLIFFE. (Price 2s. 6d.)

(2) THE ELEMENTS OF RADIO COMMUNICATION.
By O. F. BROWN. (Price 15s.)

(3) WIRELESS PRINCIPLES AND PRACTICE.
By L. S. PALMER. (Price 8s.)

(4) THE PRINCIPLES OF RADIO COMMUNICATION.
By J. H. MORECROFT. (Price 37s. 6d.))

The soldier, who has realized that "wireless" will have an increasing influence on military tactics, and who therefore wants to learn something of the principles on which it works, is at present faced with curiously

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serious difficulties. There are many popular explanations intended to enable broadcatching "fans" to receive programmes from incredibly distant transmitters; and in the proceedings of learned societies there is an all-too-copious supply of literature for the expert. But very little provision has been made for the educated reader who wants a scientific account of wireless principles in reasonably compact form.

Unfortunately, too, the official *Army Manual* is out of date; and its terms of reference were so restricted that it was never very helpful from this point of view. Military students are, therefore, compelled to rely on civilian resources.

The first book of the batch under review is one of the best to fill this need. It is very brief; it is up-to-date; and it is sound. The reader is assumed to have the general scientific knowledge of an undergraduate embarking on the natural sciences tripos physics course at Cambridge; but to be quite new to the subject of wireless. Only one brief warning is necessary about this book. In Chapter I, the author uses, as the definition of the "decrement" of a circuit, an expression which is $1/\pi$ times the value used in almost all other text-books. There is much to be said for the new definition, but students should be warned that it is as yet unusual.

Brown's *Elements of Radio Communication* can also be recommended. It is intended for readers, of no greater educational attainments, who are prepared to do a little reading every night for a fortnight, instead of wanting to get a general view of the subject at one sitting. Since the book as a whole is definitely commended, it may be worth while to record some criticisms of detail. In graphs, such as those on pages 50, 51 and 87, to illustrate the "beat" effect which occurs when two signals of different frequencies are added together, we wish the author had refrained from drawing in the dotted line "through the maximum value of the successive oscillations," and from writing such statements as ". . . we see that the effect . . . is to produce a slow oscillation in the circuit, represented by the dotted line." It is this sort of thing which encourages the heretical and far too widespread belief that the resultant current has a component of the "slow" frequency, even before the rectification which is an essential part of the heterodyne process. Other minor criticisms are that none of the amplifier diagrams on pages 107–118 indicate the need for a grid bias battery, and that there is an obvious error in Fig. 70, where the plates of all three valves of an amplifier are connected directly together.

L. S. Palmer's *Wireless Principles and Practice* is a considerably more advanced text-book. It is a useful volume in which to "look things up," but it is much more mathematical and would be indigestible fare for anyone without a previous knowledge of the subject. So many details have been included, too, that even an advanced reader is apt to lose sight of the principles. To take just one example: valve transmitters are now so definitely superior to other types, that almost the whole Chapter VI, on spark, arc and high-frequency alternator sets, would have been better left to books on the *history* of wireless.

Morecroft's *Principles of Radio Communication* is the American equivalent of Palmer's book—only more so. It is a mine of useful

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information, and the reproductions of oscillograph records which are given as practical illustrations of the theoretical equations are a most commendable feature. But woe betide any ordinary mortal who hopes to read straight through the 1,000 odd pages of this massive volume! In fairness to the author, it should, however, be added that he has published a shorter book for the benefit of those whose time is limited. It was reviewed in the *R.E. Journal* of March, 1930.

F.C.C.

MAGAZINES.

REVUE MILITAIRE FRANÇAISE.

(*January*, 1930.)—The second instalment of Général Lemoine's "*En relisant Clausewitz*" appears in this number. The writer continues to compare the present-day principles of war with those laid down by Clausewitz and finds that, in general, there is little difference in spite of modern inventions. The instalment deals first with the relations between policy, strategy and tactics; then with strategic objectives; then with forces available; and finally gives a comparison between the two forces concerned. It is not, however, particularly interesting except to a reader who is interested specially in Clausewitz's own writings.

Lieutenant-Colonel Vauthier begins "*La défense du pays contre le danger aérien*" in this number. The whole subject of protection of the country against hostile air attack is considered in detail, reference being made to the experiences of Great Britain and Italy, as well as France. Before discussing air and ground defences, Colonel Vauthier devotes considerable attention to the air intelligence necessary for air defence. As readers of General Ashmore's book, which incidentally is summarized by Colonel Vauthier, will know, a most complicated and rapid system of intelligence is essential if hostile aircraft is to be intercepted. Both the system of observation posts and the method of utilizing the intelligence gained are described. The writer then turns to the counter-attack by aircraft, first on the enemy's air bases, then against hostile aircraft in mid-flight, and finally by "defensive" aircraft near the enemy's objectives. Although the prevention of a hostile bombing expedition is obviously the ideal, Colonel Vauthier points out that attack by fighting aircraft near the objectives is probably the most effective. The instalment is completed by the realization that defence must be from the ground as well as from the air.

"*Les combats de la côte* 304 *en mai* 1916," by Capitaine Laxague, is a study of the immediate counter-attack during the Verdun battle of 1916. The actual description of the fighting is not specially interesting, but the lesson of the immediate counter-attack does stand out. The German method of attack was that of using a terrific artillery preparation on a

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narrow front, and which the French, according to Marshal Pétain, found great difficulty in countering. The French success at Hill 304 was due to the rapid counter-attack of small units far more than to counter-offensives ordered by divisional commanders. We may realize with satisfaction that the principle of the immediate counter-attack by small units is fully realized by our present-day soldiers.

"*Le gouvernement national de Nankin*," by Commandant Cornet, is an interesting sketch of the development of the Chinese revolution. He gives briefly, without an excess of Chinese names, a description of the progress of the revolution since 1911 and of the rise of the Kuomintang. As readers of newspapers know, Chiang-kai-shek is now the leader of the Kuomintang government, and is attempting to produce an orderly government out of chaos, generally on the lines laid down by Sun-yat-Sen, the great southern reformer. Commandant Cornet points out with justice that, while one cannot help admiring the ideas underlying Chiang's development of the government, it is impossible to forecast future events in a country such as China. At any rate, representatives of European powers at least treat with the Nanking government as representing China, and it is to be hoped that the country will gradually become more settled as time goes on.

"*A propos du Salon de l'automobile*," by Colonel Doumenc, is an entertaining description of the French motor show. He describes the modern car as a "singular marriage between a boudoir and a locomotive," a really apt description. After a few remarks about present-day tendencies in cars and the enormous crowd of motor-cycles, he goes on to the more serious part of the show, namely, the heavy vehicles. The modern tendency for pneumatic tyres on heavy lorries is evidently very marked. Colonel Doumenc completes his article with a description of the effect of science on locomotion, and how fresh details of the action of lubricating oil and grease can be found by the application of X-rays. It is evident, from the discoveries made, that we have still some way to go in mechanical inventions for transport.

(*February*, 1930.)—Général Lemoine continues "*En relisant Clausewitz*," dealing with a fresh series of the factors affecting modern war and showing how Clausewitz's principles still apply in general. Although the writer has obviously studied Clausewitz with great care, one cannot help feeling that so careful an analysis of his writings becomes rather tedious for the average reader.

In the second instalment of Lieutenant-Colonel Vauthier's "*La défense du pays contre le danger aérien*," ground methods of defence are discussed. The writer first deals with anti-aircraft artillery, both technically and with regard to its organization. Considerable attention is paid to the technical aspect, and the Vickers "predictor" is mentioned. The need for organization, particularly with regard to good communications, has special stress laid on it. The article then turns to searchlights, which are, of course, necessary to help the guns, and to methods of aerial barrages, which were extensively employed during the Great War. Colonel Vauthier then deals with camouflage on a large scale, including the production of false industrial areas, to deceive the enemy, and he considers that considerable advantages may be attained by these

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methods. He finally, as in the previous instalment, compares the methods of other countries with those employed by the French. It will be seen that, although concentration is wanted to absorb the article, it does give a full picture of the enormous organization required to protect a country, or a portion of it, from modern air attack.

Capitaine Albord describes the causes of the Russian disaster of 1914 in "*Le revers russe en Prusse Orientale (Août-Septembre* 1914)." Owing largely to General Ironside's book on these operations, the British officer is now well acquainted with the pathetically inadequate condition of the Russian Army of 1914. The writer brings out clearly the reasons for the Russian failure, and shows that the lessons of the Russo-Japanese war were lost on Russia. Although we can think of the almost legendary figure of the Grand Duke Nicholas of 1914, together with the "Russian steam roller," and now see how incapable the Russian Army was of fighting an up-to-date enemy, it is still difficult to realize what a mistake was made by Great Britain and France in trusting to Russia in the expected war with Germany. Capitaine Albord completes his article with a quotation from the French *Infantry Training:* "The only mistakes of commanders which should always be blamed are: forgetfulness of the mission allotted, inaction and fear of responsibility." It was exactly in these respects that Jilinsky, Rennenkampf and Samsonoff failed in 1914.

"*L'organisation du terrain et ses conséquences*," by Colonel Chauvineau, discusses the natural tendency of the defender to dig himself in as compared with the provision of field fortifications under the orders of the higher command. Colonel Chauvineau points out that the reduction of infantry during the Great War, compared to the other arms, had really overstepped the mark, and that infantry are definitely required in defence as well as more mobile weapons. He therefore appeals for better training of the infantryman in fortification, as it is impossible for all, or anywhere near all, fortification to be controlled by the engineers. If the infantryman is going to dig himself in, he should be better taught, so that a great deal of his work is not wasted.

(*March*, 1930.) Général Lemoine continues "*En relisant Clausewitz*" with a discussion of the attack. He considers objectives and direction of attack on a large scale, together with the different forms of attack, *i.e.*, turning movements, etc. Throughout the instalment Clausewitz's writings are largely quoted in support of the arguments used.

In the third instalment of "*La défense du pays contre le danger aérien*," Lieutenant-Colonel Vauthier describes the measures which can be taken in what he calls "passive defence." He regards the partial evacuation of cities as difficult, but not impracticable. From our own point of view it is hard to see how any appreciable part of London could possibly be evacuated, particularly at the outbreak of war. He then considers anti-gas measures and explains how collective protection must be better than just the issue of respirators. The difficulty in the future will be the enormous weight of bombs and the consequent depth to which dug-outs must be sunk; while the problems of ventilation and protection against gas are naturally conflicting. Colonel Vauthier then points out how the efficient use of these measures of defence depends on

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the education of the people. He concludes with descriptions of defensive measures proposed by other nations, and gives a diagram of an "ideal" dug-out proposed by an Italian colonel. One cannot help feeling that, good though Colonel Vauthier's descriptions are, it will be quite impossible to educate people to the necessary standard, at least during peace time.

"*Une manœuvre en retraite,*" by Lieutenant-Colonel De Charry, describes the operations carried out by the 43rd Division between the Aisne and the Marne at the end of May and beginning of June, 1918. This division succeeded, after a week's strenuous fighting, in re-establishing the front near Chateau-Thierry. The actual operations are rather difficult to follow, but the conclusions are of interest. Colonel De Charry points out the respective roles of the different arms in the retreat and shows clearly how difficult it is for the commander to direct his troops as they are being driven back.

Colonel Revol begins "*Initiation au voyage militaire des Alpes*" in this number. He points out that the French Alps have always offered a splendid field for training in mountain warfare, but that many officers have never had time or opportunity to study the past history of this region. This history teems with famous names, from Caesar and Augustus to Napoleon. In this instalment, after explaining the importance of the theatre of operations, Colonel Revol describes the frontiers and nationalities, followed by the routes across the Alps.

"*Rossignol,*" by Lieutenant-Colonel Pugens, is a description of a disaster which befel the 3rd Colonial Division on 22nd August, 1914. This magnificent division was surprised in the Ardennes, and in spite of the most heroic fighting, was almost wiped out. It redounds to the credit of the division that five days later, with terribly depleted numbers, it was able to inflict a heavy check on the Germans. In this instalment Colonel Pugens describes the first contact with the Germans, during which signs were not lacking of an absence of information, which was the chief reason of the French defeat.

H.A.J.P.

THE SOCIETY FOR ARMY HISTORICAL RESEARCH.

The *Journal* for January, 1930, fully maintains the high standard of production and interest that we are accustomed to in the case of this publication. Nearly half the number of pages devoted to original articles is occupied by the first instalment of *The Diary and Letters of Arthur Moffatt Lang, 1st Lieutenant, Bengal Engineers, India, 1857 to 1859, with explanatory notes, maps, portraits, illustrations, etc.* The period of main interest covered by these papers runs from the outbreak of the Mutiny till its final suppression, and will be dealt with in four clearly defined sections:—

1. 1857. Meean Meer. March to July. Outbreak of Mutiny.
2. 1857. Delhi. July to September. Siege and capture of Delhi.
3. 1857. Relief of Lucknow. September to November.
4. 1857–8. Final capture of Lucknow. November, 1857, to March, 1858.

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Lang thus took part in all the most stirring events in the Mutiny, and his share in the daring reconnaissances of the breach in the Kashmir Bastion by daylight and on the night before the assault of Delhi will be well known to all students of the Mutiny. The memoir published in the *R.E. Journal* on his death states that he was recommended for the V.C. twice during the Mutiny campaign, and mentioned four times in dispatches. The photo published with the memoir shows him as a Major with *one* ribbon, a strange contrast to modern conditions. This first section of the papers is very fully annotated by Lt.-Col. J. H. Leslie, the editor, and there are many illustrations. The second section will be edited by Col. F. C. Molesworth, late R.E.

The remaining articles are " General Sir William Howe's operations in Pennsylvania, 1777," " The Colours of the British Marching Regiments of Foot in 1751 " (a continuation), and " Canadian Sketches in 1805–6." Reviews, Notes, Questions and Replies complete a very interesting number. It only remains to add that the Society, which is doing so much for the Army in its own particular line, is always glad to welcome new members.

P.H.K.

MILITAERWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*May–June*, 1929, *continued*).—*The Crossing of the Danube at Krems*, 1927. The crossing of large rivers in mobile warfare makes extraordinarily high demands on officer and man, and presupposes the existence of a sufficiency of well-trained technical troops and of ample equipment.

If such a crossing is carried out as a peace exercise the most essential war-factor, disturbance by hostile action, is absent; but against this there occurs a host of other difficulties, peculiar to peace, which can with difficulty be overcome or circumvented.

Amongst these peace difficulties are—as in the present instance—lack of labour and lack of materials. Design and execution of this crossing of the Danube must be judged with these limitations in mind.

As owing to the great increase of traffic-loads, as compared with pre-war loads, heavy bridges will be the rule in future, and as a medium bridge had been built in 1925, a heavy bridge was chosen for this year's exercise; width of crossing, 315 metres, maximum rise and fall, 16 feet. In deciding on a heavy bridge, the military authorities had not allowed sufficiently for the restrictions of the local river authorities. The total length of bridge to be carried on piles was cut down to 80 metres, and only six hours could be granted on one day for the total suspension of river-traffic. Three 25-metre spans of iron road-bridge, system Herbert, were put in on three single pile-trestles with adjustable transoms, and two spans of 25-metre Herbert girders, carried on rafts, each consisting of two 45-ton iron boats. With, thus, only 145 metres, or less than half-way, covered by heavy bridge, peace limitations began to weigh heavily, and it became necessary to assume that

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the completed portion of heavy bridge was all that remained of a heavy bridge after enemy bombardment, and the remainder of the exercise became the completion of the crossing by medium bridge. This was done accordingly by means of three spans of 15-metre Herbert girders carried on rafts of large pontoons (7 partitions), covering 53 metres, and 116 metres of heavy Birago pontoon equipment, including a 38-metre cut.

The report, which was drawn up under the orders of the General Staff, is accompanied by four plans and twelve good photographs. It claims finally that the crossing at Krems proves that the pioneers of the new Austrian army, if inferior to their predecessors in numbers and equipment, are not so as regards their powers of work and keenness.

Technical Progress of Aircraft Construction and its Influence upon a Future War, by Captain Ritter, of the General Staff. In the Great War the stage of development of aircraft did not allow of air-forces being more than auxiliary to land-forces and sea-forces. It did not open up an entirely new field of activity for the political by acts of violence to overcome the enemy nation's will to war; but there were the beginnings of such opening in the bombing attacks on London and Paris in 1917. The author then works out that at that time it took 24 bombers to produce half a ton of effect. Further, he states that approximately 112 tons of bombs were dropped on London in 27 attacks, covering a period of twelve months. The number of persons killed was 836, and wounded 1,965. It is clear that material effect on this scale could not extinguish a nation's will to war. It had, in fact, an exactly contrary effect in exciting bitterness and the desire for revenge.

The object of the article is then to consider how far the technical progress of the past ten years justifies the opinion that, in a future war, the role of the air-arm will be both more important and more independent.

The author considers at some length the factors and developments, and leads logically to the following conclusion:—An air-fleet could not be used worse or more ineffectively than by being called upon to perform the almost impossible task of seeking battle with the hostile air-forces, and to devote its strength chiefly to this task. Objects against which the activities of the air-fleet may be directed with some prospect of success must be either fixed targets, like towns, industrial establishments, communications, aerodromes, etc., or targets which, although capable of moving, are relatively so slow compared with aircraft, that with anything approaching good reconnaissance and intelligence work they can certainly be brought to book, *i.e.*, land- and sea-forces.—(*To be continued.*)

Austrian and German Military Laws. A lecture by the Austrian Judge-Advocate-General, Dr. Hecht, which compares the present military laws prevailing in the two countries. This subject owes such interest as it may awaken in Austria and Germany to the present general tendency to bring laws, policy, administration, organization, etc., into line in order to facilitate a possible future union; a tendency of which another expression is the interchange of officials for periods

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of attachment. For foreigners the chief interest lies, not in the comparison, but in the spirit which breathes from such an utterance as that the armies of Austria and Germany "are the firm foundation upon which will be built up the conscript armies of the future."

The Austrian Army of To-day, by Colonel Schubert. At the Armistice a large proportion of the German-Austrian troops, who during over four years of warfare had always had more than their share of "sticky" places, were on the Italian front and there fell into "After-the-war-prisonership." All those who returned home were immediately discharged, owing to the new republic having no army.

The politicians, however, started creating a People's Defence Force, which by the end of December, 1918, had reached a strength of 1,700 officers and 58,000 men. This force was run on social lines, the Soldiers' Council and the Commanding Officers forming a dualism. The conditions in Vienna when this army commenced its career were so unpromising that the prophecy regarding it made by a General of the old army, is recalled:—"Produced by poor parents in domestic discord, it has a hard youth ahead." The hard youth anticipated is now past, and the army, which was wisely bound on to the traditions of the old army, has made good in every way. It is probable that this success is in great measure due to certain concessions forced at the outset upon the Social-Democrats by their more conservative opponents, the Christian Socialist party; which included the removal of the army entirely outside politics, the limitation of the powers of the political agents, especially as regards commanding officers, and facilities in the matter of taking over officers of the old army.

The article contains many interesting photographs of the army's varied activities, including two of emergency engineering operations, and others of mountain-guides on skis, and of training in ice-technics on a formidable glacier. For further information one is referred to *Oesterreich's Bundesheer*, published by M. u. T. Mitteilungen, Vienna; price sch. 5/-.

The Crossing of the Piave by the British in October, 1918. A translation of Major Kerrich's article in the *R.E. Journal*, December, 1927. The translator makes a few comments at the end. He cannot pass the claim as to greatest length of bridge, and mentions other bridges varying in length from 550 metres to 966 metres and over. His principal comment is:—At nearly every opposed river-crossing two crises can be observed. The first occurs after the landing of the first party to be shipped across, when, through hostile action or lack of engineers and means of crossing, the transhipment of the following parties is either delayed or becomes impossible. When the crossing proper has been gained and the forces established in the bridgehead, small or large as the case may be, have to keep off systematic hostile counter-attacks and to preserve communication between the banks from interruption, then begins the second or more critical stage of the river-crossing. This crisis lasts nowadays longer than formerly owing to the exposure of the bridge to destruction by aircraft, as well as owing to increased ranges, and remains even when the line has been pushed far beyond the point of crossing.

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Lieut.-Colonel Kubitzka, who was in the Papadopoli sector in August and September, 1918, doubts from his own experience whether the crossing described would have survived these two critical stages, if it had struck against a firm defensive front. He points out that at the end of October, when divisions were already marching home, no counter-attack was possible. Of which fact cognizance was taken in the *R.E. Journal*, March, 1928, p. 175.

The Development of Artillery Material since 1914 (*continued*). Comparatively little is known about modern British artillery material, and almost nothing about the heaviest of the land-army. This is for the greater part due to British reticence, everything above 9·2″ being kept secret; and partly also because only in a few cases have British firms supplied foreign armies. The description of British heavies on movable mountings is hence confined to the 9·2″ Howitzer Marks I and II, and the 12″ Howitzer, also by Vickers, built for the Russians. The performances of the first and last named Major Heigl considers "weak," and of the 9·2″ Mark II "not great." At that, like all British guns, they are heavy. He would say "much too heavy," but for recognizing that being designed for use in flat country there has been a costly preference for the lower angles, whereas the Austrians, with their mountain frontiers, prefer the upper group. The Austrians never having built such guns can hardly look upon the enormous weights of the English guns as constructional faults. It is quite another story when we come to judge the English guns from a constructional point of view. "We are giving no secret away when we say that by those best qualified to judge among their allies, *i.e.*, among the French and the Americans, the English constructions are generally looked at with an indulgent smile, sometimes with a shake of the head; and that the Italians, whose technical judgment is extraordinarily clever and impartial, while acknowledging the precision and robustness of these English guns, adopt the same attitude."

Major Heigl dissociates himself from these judges. The heaviest British mortars were built literally for rapid fire. He recalls Cambrai and the 8th August, the "black day" of Amiens, and reminds his comrades who were opposite to the British in the Montello sector, and in the Sieben Gemeinden, of the deluge-like inundation of a hostile battery by large-calibre projectiles which was the British method. The advantage of his experience has helped Major Heigl to a better understanding.

Technical Progress of Aircraft Construction and its Influence upon a Future War (*concluded*). Having decided so clearly against what objects the attacks of aircraft can and cannot be directed, the author proceeds to the problem of the tasks to be imposed upon aircraft in a future war. The state of technical development now reached gives air-forces, in addition to their original role as auxiliary to land and sea-forces, another and independent role as a third weapon to the army and navy for the political furtherance of war. The author confines himself to a consideration of this independent role.

The object of war is the destruction of the enemy's will to war. This will to war has three chief supports, which are in the order named,

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(1) the will to war of the hostile nation, (2) the country of the enemy as the material source of his power to conduct war, and (3) the enemy war-forces.

Sea- and land-forces can generally only affect (1), the most important of these supports, indirectly by successful action against (2) and (3), *e.g.*, by blockade or occupation, and by battle respectively.

Air-forces can, however, attack directly the first and chief support. Whether they will do so or not must depend upon circumstances, which determine their likelihood of success. Even gas and incendiary bombs may not add sufficiently to the horrors inflicted upon civil populations by hostile aircraft attacks, to destroy their will to war, where the people are willing, patriotic, disciplined and protected, or the scale of such operations is too small. When direct action against civil populations is not of sufficient promise, the independent air-forces will co-operate with sea and land-forces upon the only lines possible to these latter arms.

Having settled the methods of employment of air-forces, Capt. Ritter devotes the remainder of his article to the means at their disposal for attacking the chief support to the enemy's will to war, *i.e.*, the will of the people, or its support of next greatest importance, the material sources of its war-power.

The Official Austrian History of the War. A review by Major-General Kerchnawe of the second of six parts of Vol. I, which dealt with 1914.

Vol. I, price sch. 45/-, was issued complete in December, 1929—publishers, M. u. T. Mitteilungen, Wien I, Stubenring 1.

The Advance of the Soviet Power in Asia. A review by Colonel Paschek of Cleinow's *Zum Aufmarsch der Sowjetmacht in Asien*, published by Reimar Hobbing, Berlin: large 8vo, 426 pp., 12 maps and 47 pictures.

The object of the book is to fill a special gap in the literature of Asiatic problems. Cleinow travelled from Kusnetzk to the Altai Mountains making studies on behalf of a German scientific society. He deals principally with the valuable portion of Central Asia, to so-called New Siberia, or Sibkrai, that is the territory along the railway from the R. Irtish to Lake Baikal, and southwards to include the Altai Mountains. It thus appears to include the greater portion of Mongolia, all except the Gobi Desert. Cleinow estimates that there is room here for 80 million inhabitants, subsisting on agriculture, cattle, forestry, mining and allied industries. He considers the opening up of this country of enormous importance to Russia, as the key to her military position in Asia, and he looks forward to Germans being given a hand in the process.

The Mobilization of Industry. A description of the measures to this end taken in the United States, starting with the National Defence Act of June, 1920, the officials concerned, their duties and activities. The Assistant Secretary of War is said for this purpose to have secured the co-operation of over 600 leading representatives of technics and industry, and to be in touch with over 10,000 factories and other undertakings in various districts.

F.A.I.

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HEERESTECHNIK.

(*July*, 1929.)—*The Influence of the Technical Development of the Fire-arm on Infantry Tactics* (*concluded*). In a series of articles with the above title the author does not consider himself called upon to take up any direct attitude towards the actual unsolved problem of rifle and machine-gun, of which he has given us the extreme opinions, viz., on the one side, that the rifle must remain the infantry's chief weapon, with all other infantry weapons auxiliary to it: and on the other side, that the role of the rifle is played out, and the machine-gun must take its place. He has, however, to consider and judge upon the capabilities of all the infantry weapons. Of the rifle itself he says that it came up to all expectations at the commencement of the War. That its effect was ranked so low at the end of the War was due to the infantryman, who had been highly trained in its use, having almost entirely disappeared. The rifle remains the same, a weapon of good precision at short ranges, but also a long-range weapon. The heavy machine-gun likewise remained technically the same as when the War began. It is an excellent long-range weapon, irreplaceable by even a comparatively large number of rifles. It is also unsurpassable at even the shortest ranges, *e.g.*, against infantry assault. In addition, it possesses the possibility of tackling effectively an invisible opponent by means of indirect fire, where rifle-fire would under the most favourable circumstances be inadequate.

The light machine-gun, born of the necessities of trench-warfare and of fighting in the air, is a short-range weapon, and hence only an auxiliary. If the automatic pistol had come earlier and in sufficient numbers it might, at any rate partly, have taken the light machine-gun's place. All other infantry-weapons, the automatic pistol, the hand-grenade, the rifle-grenade, the trench-mortar, are dismissed shortly as auxiliaries. Upon the comprehension of all these different weapons to a combined effect the principles of fighting-formations must be built up. It is the task of tactics so to shape the latter that the capability and particular nature of each kind of weapon is fully utilized in this co-operation.

If it was attempted in the present state of affairs to earmark the rifle again as the principal infantry-weapon, it would show an incorrect appreciation of its powers. The fire of m.g.s is, as things stand, far superior to that of rifles. But the rifle is entirely capable at all ranges of furnishing a supplementary to m.g. fire, which must by no means be undervalued. To use it as a short-range weapon of precision would be to waste its capabilities. As much could be done with a less perfect weapon and with less powerful ammunition. Moreover, the technical development of the rifle is as yet incomplete. Automatic rifles exist already, and there is no reason for believing that the difficulties cannot be overcome of producing an automatic rifle, suitable as an infantry-weapon, and firing its whole magazine without removal from the shoulder. Such a weapon might well make the light m.g. unnecessary: it is very doubtful whether it would essentially diminish the importance of the heavy machine-gun.

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Fresh forms of tactics would, of course, follow the introduction of so great an improvement in the existing rifle, and the wishes of the exponents of the rifle as principal infantry-weapon would gain in importance; but even then it is doubtful whether the rifle will ever regain the prominent position of, say, the flintlock with bayonet.

In our technical age the machine, and that the simplest fire-arm has always been, can always do without the man more and more, only never entirely so; while the man can always less and less do without the machine.

It will be noticed that in the foregoing no attempt has been made to go into the effect which the artillery has always had upon the forms of infantry tactics. This has been done on purpose to emphasize the influence of the infantry-weapon, even at the risk of somewhat distorting the picture.

The Advantages of the Diesel Engine for Aircraft. Taken from an article in *Automotive Industries*, December, 1928, and of interest because the conclusions arrived at are based upon extensive trials in the United States.

The two most important requisites of an aircraft engine are safety and reliability; and these are both the Diesel engine's strong points. A flash-point of 70°C for heavy oil, compared with 7·5°C for aeroplane petrol, means the diminution, if not complete removal, of that danger of fire which exists with all aircraft using petrol. In working in the laboratory on new types of petrol engines for aircraft, fires are more or less a daily occurrence. During the time, nearly a year, in which work was going on in the laboratory on the new Packard-Diesel aircraft engine, no single case of fire has occurred, owing to a stream of oil running over the hot engine. All experiences justify the statement that fire on a Diesel-engined aeroplane after crashing is almost impossible. As regards reliability the Diesel engine has a great advantage over the petrol engine, owing to there being no magneto and no carburettor. Comparing the ignition system of a 9-cylinder Star-engine petrol-driven with a 9-cylinder Star Diesel engine, the former needs two independent sources of ignition-current, batteries or magnetos, two feeding-systems for the same, 18 high-tension leads, 18 sparking plugs, etc., perhaps a grand total of one thousand separate parts: the latter firing by compression requires no further parts, and ignition is secured as long as the engine works. Further, the ignition of each separate cylinder is entirely independent of the others, so that it has as many ignitions as cylinders, while the petrol engine of similar type depends on the functioning of two separate systems each of which consists of a number of parts, each of which is liable to failure.

The greatest advantage of the Diesel engine for aircraft is not mentioned in the article, since it does not apply to the United States, the world's greatest oil producer. It is, that a country like Great Britain, possessing coal, but no oil, could, since the heavy oil on which the Diesel engine runs is obtainable from coal, regain that supremacy based upon coal which is jeopardized by our dependence upon other countries for the petrol we need in war.

The Camouflage of Sound. A plea for the extension of camouflage

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to include sound. The sphere of observation having been extended by aircraft, movements take place more and more under cover of darkness, or mist, natural or artificial. Increased importance is therefore to be attached to an absence of all betraying noise, to its avoidance, diminution, or concealment by other sounds. Above all, owing to the success of sound-ranging it is necessary to suppress the noise of gun-discharge; and much has already been achieved to this end by mechanical means, by chemical means, or by both combined.

The head-wave (*onde de choc*), which precedes the report of the gun, whenever the muzzle-velocity exceeds the speed of travel of sound, requires also to be dealt with, and appears as yet to have defied all efforts at treatment.

The German Air-map. Taken from *Nachrichten für Luftfahrer*, 1929, No. 25. Apart from provisional maps for airmen produced during the War, the first steps towards a German air-map were taken in 1926. First, a sheet of 1 in 200,000 was drawn up according to requirements laid down by the Aviation authorities. A recognition, however, that the increasing speed of aircraft would make a map on so large a scale unlikely to last, led to the first proposal being abandoned, and an attempt was made at 1 in 300,000 to satisfy the requirements of the aviation authorities, with corresponding modifications. The result was not satisfactory. A solution was then sought on quite fresh lines. Aviation was using exclusively the Government Survey Office General Map $\frac{1}{300,000}$, originally made as a military route-map, and by no means ideal for use as an air map. It was decided to use this map as the basis of a new map. An ideal air map can indeed not be obtained by the alteration of an existing map; but financial considerations rule. As it is, it will take ten years, with the existing personnel, to convert the 51 existing sheets of this map into an air map, preserving rivers, woods and ground-form, and all important names, and omitting all superfluous detail. This will cost one-quarter of what an entirely new map would cost, and take one-quarter of the time to produce. The new air map will be both more distinct and more legible than the present $\frac{1}{300,000}$. It will fulfil the two main requirements of an air map, viz., enable the airman to locate himself, whatever his height; and call his attention to things he ought to see, like wet meadows, power-lines, etc. Rivers and railways, being important for orientation, will be sufficiently emphasized. The same with large woods; but the reproduction of all details of the shape of woods, and the existence of small plantations, afford difficulties which are unavoidable as they arise from the scale. As 300 metres is represented by 1 mm., a wood smaller than 300 m. × 300 m. cannot be shown. The representing of villages also provides difficulties. Towns are shown in their outlines, but villages by means of a circle, or if there is a church, by a circle with a cross in it. These circles are only correct in that the centre of the circle coincides with the centre of the village: they give neither extent nor relative size. The showing of village shapes can only be done to the prejudice of other things more important for orientation.

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Roads are taken from the General Central Europe map 1 in 300,000. It is seriously to be considered whether considerable simplification might not be introduced, *e.g.*, retain only the main roads. The chief difficulties are that only the man in the air can decide which are the roads he wants to see on the map, and that it is much easier to leave out a road than it is to put it in again. The greatest difficulty of all will be showing the heights. Levels shown by different colours would certainly be best; but the colour-plates for the height-levels will have to be cartographically entirely redone. Names will be much reduced: the qualification for a village to have a name will be the possession of a railway station.

Admitting that an ideal air map cannot be obtained in this way, a real improvement on the present state of affairs is aimed at.

The Detection of Mustard Gas. The Red Cross convened at Brussels a committee of experts, at the instigation of which it offers now a prize of 10,000 Swiss francs for international competition for the best re-agent for recognizing mustard gas. Considering the ready reaction of mustard gas with all oxidizers, even furious reaction with bleaching-powder, and the ready and widely distributed response to it of the human body —*experto crede*—one suspects a snag. Here it is: the committee demand a recognition of ·7 milligramme per litre of air. The competition closes on 31st December, 1930, and the prize may be distributed to two or more competitors.

(*August* 1929.)—*Accumulators.* Compares the two types of accumulator used in the German Army in the wireless service. They are a 2-cell lead accumulator, and the Edison accumulator, in which the electrodes of each cell are four nickel and two cadmium plates, and the electrolyte is KHO. Regulations for the charging, use and care of both sorts are laid down in H.Dv 493 (50). The lead accumulators are superior electrically; the Edison, mechanically, and are used where weight and space are considerations; also where they are liable to be shaken or misplaced. A weak point in the latter is the means of closing, but a new valve-like stopper has been devised with very small holes, which allows the accumulator, once it has stood for three hours after charging, to be turned upside-down without loss of electrolyte. This device has passed satisfactory trials and is now being tried out by the troops.

The Advantages of the Diesel Aircraft Engine (*continued*). What is always looked upon as the chief advantage of the Diesel engine, viz., the saving by running on heavy oil instead of on petrol, is relegated by the author to third place, after safety and reliability. This is done because he considers the two factors last named as of much greater importance for the growth of the industry on sound lines. When the superiority of the Diesel engine for aircraft regarding safety and reliability is established in people's minds, then the decisive factor in favour of its introduction will be the economic one. The saving compared with petrol divides into (*a*) 20% decrease in fuel-consumption, (*b*) 70 to 80% decrease in cost of fuel, (*c*) owing to greater reliability a reduction in the number of engines of larger aircraft, less running costs, and less maintenance.

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The crux of the whole matter would, however, appear to lie, not in any one of the three advantages claimed, nor in robustness, nor in weatherproofness, nor in all of these combined, but in whether the Diesel engine can replace the petrol engine in its suitability for aircraft from the airman's point of view. This has certainly not been the case during the twenty-five years in which it has been known and used for stationary and marine engines. Slow speed and lack of elasticity have stood in the way of its introduction, even for automobiles. The solution which has enabled the Diesel engine to become a competitor in the air lies in the production of the high-speed Diesel engine (1,400 to 1,500 revs. per min.). Since a Diesel aircraft engine has to run five or six times as fast as a stationary or marine Diesel engine, the ignition-point being approximately the same, the h.s. Diesel engine demands entirely different combustion from the low-speed. Oil injection with the h.s. Diesel must start 50° before the upper dead centre, if complete and smokeless combustion is to take place, whereas in the l.s. Diesel engine oil injection starts about 10° before the upper dead-centre and lasts to about 32° beyond it. Thus with the h.s. Diesel the work-cycle does not differ much from that of the petrol engine. The chief difference is that with the petrol engine at the moment of ignition the whole charge is in the cylinder, while with the h.s. Diesel at this moment only a small percentage of the charge has been injected. This circumstance enables the designer to keep the rise of pressure in the cylinder within defined limits.

It is instructive that this assault upon the petrol engine's position should come from the United States, the country above all others which is least interested in fuel for aircraft being derived from coal instead of from oil.

Military Technical Problems in the Most Recent Literature. Kaiser and Army, by Lieut.-Colonel Niemann, is a book about William II., which does full justice to the Kaiser's interest in the army in peace-time, and the many technical improvements he helped to bring about. "His practical aptitude for science enabled him to keep pace with the feverish development of his times." Amongst the activities mentioned are, the inclusion of heavy artillery in the field army, the timely creation of technical troops, the provision of co-ordinated systems of frontier-fortresses, the development of the railway network, up-to-date equipment of the medical services, etc. It was no fault of the Kaiser's that Germany had made insufficient material preparation for war. Here he found the political situation against him, an attitude which the author says was "due to an erroneous impression that war would be short and would quickly lead to a decision."

"Thoughts of a Soldier," by General von Seeckt. The late Chief of the General Staff sketches the war of the future, discusses the means to mobility, the impossibility of keeping national armies abreast of the rapid progress in technics, co-operation with industry, modern cavalry, the place of the tank, etc. Almost all that he writes is interesting and much of it is worthy of study. Some thought-splinters are, "The modern Cavalry Division will need to be entrusted to a modern Seydlitz"; "Against technical means of attack equal technics has always found a

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defence"; "It is quite wrong to speak of the victory of material over man. Material has conquered man in the mass, but not man himself, and never will do so, since it only gains life in man's hand."

"Armament and Disarmament," by Colonel von Oertzen, reviews in a capable manner modern armies and armaments. It might have been written in response to a remark of the Minister of Defence at the manœuvres in Schelsia, when he recommended, owing to Germany's restrictions in this respect, the necessity for German officers to study the efforts, experiences and successes in technics in foreign armies.

F.A.I.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1930. TOME I.—NOS. 1 TO 3 INCLUSIVE.)

Les opérations de l'Armée belge, 1914–1918. The events of the period June 6th, 1916—July 7th, 1917, are dealt with in No. 1 of the *Bulletin;* the general situation at this time is briefly reviewed. At a Conference held at Chantilly on November 15th and 16th, 1916, it was decided that plans should be prepared for a new offensive to be launched in February, 1917. A plan of operations was accordingly worked out; it was approved by Joffre, who, however, handed over command of the French Army on December 16th, 1916, to Nivelle. The latter introduced some modifications in the plan, and the date for launching the offensive had for various reasons to be postponed from February to April, 1917. In March, 1917, the Germans fell back to the Hindenburg Line; this move necessitated new dispositions on the Anglo-French front.

The British offensive in Artois was launched on April 9th; the operations continued until May 4th (Battle of Arras, 1917): the effort met with success, but no decisive result was obtained.

The French main attack was delivered in the region of the Aisne on April 16th (Second Battle of the Aisne), but was unsuccessful. In consequence, Nivelle was superseded, and Petain took command of the French Armies on May 17th, 1917.

The Italians did not launch their offensive until the middle of May; they obtained a substantial initial success in the region of the Isonzo, and desultory fighting continued for some weeks.

A revolution having broken out in Russia in March, 1917, the Russian Army, which was then under the influence of the Bolshevists, remained inactive. Fortunately, the United States of America now decided definitely to support the Entente Powers, and declared war against Germany on April 17th, 1917.

The Belgian Army was during this period engaged in minor operations on a front extending along the Yser Canal; its right rested at Boesinghe. A scheme was prepared for landing a portion of the British Army on the Belgian coast behind the German right flank, and it had been intended that the Belgians should take part in the proposed operations. The scheme was not carried out, but an outline is given in No. 1 of the *Bulletin* of the role assigned to the Belgian Army therein.

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Particulars are also given of the preparatory work in connection with the scheme and the raids which were carried out by the Belgians.

The events of July 7th—November 13th, 1917, are dealt with in Nos. 2 and 3 of the *Bulletin;* the Second Battle of Flanders occupies the chief place in this part of the narrative. Although the operations in question did not free the Belgian coast, important tactical successes were gained and heavy losses inflicted on the German Army.

The French gained successes in minor operations carried out at Verdun (August 20th/26th) and at Malmaison (October 23rd/26th); in the latter case, the Germans were obliged to withdraw their troops from the Chemin des Dames.

In the other principal theatres, affairs took a most unfavourable turn, so far as the fortunes of the Entente Powers were concerned. On the Eastern Front, Brousiloff met with a temporary success in E. Galicia, but his troops were permeated with Bolshevism, and, in mid-July, when the enemy struck his first serious blow, the Russians gave way and a panic ensued. It was only when the confines of Bessarabia were reached was Korniloff, Brousiloff's successor, able to stem the invaders' advance. In the midst of these disasters, the Roumanians put up a stubborn fight on the Sereth.

At the beginning of September, just when the situation had been restored on the Russian Front, the Germans seized Riga by a surprise attack, and, in October, occupied the islands in the Gulf of Riga without any great effort. On November 8th, Lenin and Trotsky took over the reins of government in Russia, and two weeks later opened negotiations with Germany for an armistice. Freed from anxiety as regards Russia, the enemy launched a powerful offensive against the Italians on October 24th in the Frioul region; the Italian Second Army met with a serious defeat at Caporetto. The whole Italian Army now fell back; it was able, however, to take up positions on the Piave, and the enemy's advance was definitely checked on November 10th, although fighting continued up to the end of December. Supports were at once rushed from the Western to the Italian Front; the transfer of reinforcements (six French and five British divisions) began on October 28th, and continued for some weeks. French units took their place in the Italian line on December 4th.

An Inter-allied Conference met on November 17th, 1917, in view of the seriousness of the situation; its labours resulted in the preparation of a scheme for the creation of a Superior Inter-allied Council of War.

A brief outline is given of the Battles of Ypres, 1917. Further particulars are also given of the scheme relating to the proposal to land a British force in the neighbourhood of Ostend. It was proposed that a Franco-Belgian Army of the North, consisting of six French and six Belgian divisions, should be constituted and placed under the Belgian King; it was intended that this Army should cover the left flank of the British force detailed to operate against Ostend.

The text of a memorandum from the Chief of the Belgian General Staff to the C.-in-C. of the French Northern and North-Eastern Armies is published in No. 2 of the *Bulletin;* therein, it is pointed out that

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constitutional reasons made it impossible for King Albert to accept the command of French troops. It is also stated that, in the opinion of the Belgian General Staff, the chances in favour of the success of the proposed landing operations were small and, in consequence, the Belgian Army could not participate in the scheme.

The text of the Convention dated June 17th, 1917, which was entered into by Petain, Haig and Ruquoy (Chief of the Belgian General Staff) in relation to the operations to be undertaken by the three British Armies, the French First Army and the Belgian Army during the summer of that year, is published in No. 2, and the preparations which were made to give effect to the scheme are briefly described.

The operations of the Belgian Army, known as the Battle of Flanders, 1917, are described in No. 3; a tabular statement shows the minor operations carried out between October 20th and November 12th, 1917, by the Belgian Army.

L'attaque des objectifs au sol par l'aviation allemande. The original article is contributed to No. 1 by Capt. Commandant Van Derr Donckt, who points out that during the first weeks of the Battle of the Somme, 1916, the pilots of the Entente formations acquired a dominating position in the air warfare; their unchallenged supremacy produced a demoralizing effect on the German troops. References to this subject in German publications are mentioned in the original article, and extracts from some of them are quoted. The German High Command felt that the only satisfactory way to meet the situation would be by carrying out vigorous counter-thrusts. Accordingly, during the winter of 1917/1918, in preparation for the offensive of the following spring, von Hoeppner, the C.-in-C. of the German Air Force, assembled selected officers of the air arm at G.H.Q. with a view to studying their battle problems at a Kriegspiel. An account of the conclusions arrived at on that occasion has recently been published by Colonel Jochim. The present-day German air tactics are based on the lessons of 1918, and as this subject is of equal interest to the Air Force and the Army at large, a brief review of the salient features of the German practice has been compiled for the *Bulletin*.

L'organisation militaire de la Pologne. An outline of the military organization of Poland is contained in No. 1 of the *Bulletin*. Military service is compulsory; obligation to serve begins, in peace time, as soon as a young man is 21 years of age, and, in war time, as soon as he reaches his nineteenth birthday. Young men may also enrol voluntarily as soon as they are 17 years of age. Service in the Active Army lasts two years, except in the cavalry, and in the marines—in the former the recruit serves for 30 months and in the latter for 27 months. Service in the Reserve continues until officers reach their fiftieth birthday and those in the ranks reach their fortieth birthday. Finally, ten years have to be spent in the Landsturm.

A Committee of National Defence exists for studying all problems relating to the defence of the country. The President of the Republic is the Chairman of this Committee, the members thereof being the Prime Minister, the Ministers of War, of Foreign Affairs, of Finance, of the Interior and the Inspector General of the Forces.

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In peace time, the Minister of War is C.-in-C. of the Polish Army, the Inspector General and General Staff being directly under him. The Inspector General is the officer who has been selected for the position of C.-in-C. in the event of an outbreak of hostilities.

Poland is divided into ten military regions, an army corps being located in each of them. The peace establishment consists of 28 infantry divisions, two divisions of chasseurs, four cavalry divisions and six independent cavalry brigades. Each infantry division comprises three infantry (or chasseur) regiments and a field artillery regiment. Each cavalry division comprises three brigades (each of two cavalry regiments), two horse artillery brigades, one pioneer squadron and one machine-gun squadron. Each independent cavalry brigade comprises three cavalry regiments, one horse artillery brigade and one pioneer squadron.

The distribution of engineer units among the various formations is not stated; the Corps consists of ten sapper regiments; two railway regiments; two signal regiments and three independent signal battalions; one radio-telegraph regiment; one electro-technical battalion; one heavy bridging battalion.

The estimates for 1928/9 provided for a peace establishment of 17,100 officers, 37,000 N.C.O.s, 198,000 men and 1,724 cadets; a grand total of 253,824 all ranks. The population of the country was 30,212,900 at the end of 1927.

Un épisode de la défense de Liége. The original article is contributed to No. 2 of the *Bulletin* by Capt. F. Vandaele, who points out that few incidents of the Great War excited greater alarm than the commotion which occurred at daybreak of August 6th, 1914, in front of General Leman's headquarters at Liege. It was supposed at the time that an attempt to seize the person of the Governor of Liege had been made by German soldiers who had entered the town before the declaration of war and had remained in hiding until the opportune moment should arrive for them to carry out their special mission as a part of the plan for the *attaque brusquée* against the Belgian fortress. The truth in relation to this episode has been made public in many German narratives dealing with the War. The history of the 7th Bn. Prussian Chasseurs, one of the companies of which was involved in this incident, has recently been published, and provides material for dealing with exactitude with the whole of the facts leading up to the episode in question. Capt. Vandaele's article is based on this document, and he describes in some detail the adventures of No. 1 Company of the above-mentioned battalion; it became separated from the main body and passed through the Belgian defences at an undefended point. The inhabitants, thinking that the little band was the advance guard of British reinforcements which had suddenly arrived among them in the northern outskirts of Liege, not only gave the Germans a rousing welcome, but actually acted as guides to them and led them direct to the Governor's headquarters. The cheering of the crowd outside the building attracted the curiosity of a staff officer; he went to a window and, recognizing the German uniform at once gave the alarm. Fire was opened on the Germans, who replied.

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It is evident that on this occasion the Germans did not pay heed to the lessons inculcated in military text-books. The story that is told shows brigade and company commanders pushing forward with their troops, without having taken the trouble to obtain intelligence of the enemy's whereabouts, and without any arrangements for maintaining liaison between the several portions of their commands; and, what is perhaps the most serious fault of all, without adopting the usual elementary measures for the protection of troops on the march.

L'organisation de la Défense Nationale en Italie. The original article appears in No. 2 of the *Bulletin*. The subject dealt with is treated under the following main heads: (1) General review of the problem of National Defence in Italy; (2) The Supreme Control; (3) The Army; (4) The Air Force; (5) The Navy; (6) Miscellaneous matters; (7) The Mobilization of the civil resources of the country; and (8) Remarks.

The original article contains much matter of considerable interest; only a few of the subjects dealt with can be touched upon here. The information contained in it is based partly upon contributions by Commandant Conquet to the *Revue Militaire Française* for November and December, 1929 ("L'Armée italienne en 1929") and by Capt. Touret to *La Revue d'infanterie* for June and July, 1928 ("L'infanterie italienne).

Comdt. Conquet considers that the Italian military system is particularly well adapted to meet the conditions imposed by the geographical considerations and the economical situation. Italy, he points out, consists of three distinct regions, which he names, "l'Italie continentale," "l'Italie péninsulaire" and "l'Italie insulaire"; each of them possesses a distinctive characteristic of its own. Northern Italy—*l'Italie continentale*—is by far the most important region; it is the most densely populated, richest and the most highly industrialized part of the kingdom, containing as it does three-fifths of the whole population, 90% of the metallurgical and 75% of the hydro-electric enterprises of the country. It is essential therefore that the measures adopted for the protection of this region should be adequate.

Important economic and political centres, such as Genoa, Rome and Naples, are situated in *l'Italie péninsulaire;* this region is by reason of its configuration extremely vulnerable.

L'Italie insulaire comprises Sardinia and Sicily, which constitute advanced bastions jutting out into the sea; this region provides a strategic position of incomparable value, a part of it situated, as it is, in the zone where the two Mediterranean basins meet.

Italy possesses a kind of Super-Ministry for the purposes of the supreme control of National Defence. Signor Mussolini, as Head of the Government, has for some time personally controlled the Italian Ministry of War, the Admiralty and the Air Ministry and is assisted in this task by a Chief of the General Staff, who, in peace time, issues "general directives" to the Chiefs of the Staff of the Army, of the Navy and of the Air Force respectively; he would, in war time, be a kind of generalissimo of National Defence. In no other country is there an officer with responsibilities and duties exactly similar to those of the Chief of the General Staff here mentioned.

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The framework of the military hierarchy in Italy is constituted as follows :—

1. *The Supreme Command.*
   The King.
   The Prime Minister.
2. *Organ of co-ordination and preparation.*
   The Chief of the General Staff.
3. *The Executive Organs.*

	Army.	*Navy.*	*Air Force.*
Technical duties ...	General, Chief of Staff.	Admiral, Chief of Staff.	General, Chief of Staff.
Administrative duties ...	Under-Secretary of State, Ministry of War.	Under-Secretary of State, Admiralty.	Under-Secretary, Air Ministry.

The above organization has been designed with the object not only of ensuring unity of direction and continuity in matters affecting national defence, but also so as to provide for the co-ordination under the best possible conditions of the roles assigned to the several groups forming the national defence force.

The Italian Land Forces are permanently organized in armies (of which there are four) ; army corps (of which there are 12) ; and infantry divisions (of which there are 30). There are 111 infantry regiments, one tank regiment, 67 artillery regiments, 12 cavalry regiments and 17 engineer regiments in the above formations.

In 1918, the Italian Air Force possessed 2,600 machines ; it was subsequently much neglected and almost ceased to exist. Signor Mussolini, recognizing the important part this arm will be called upon to play in the future, created an Air Ministry in 1925, and personally took charge of it ; he has done much to foster the growth of this arm and to promote its efficiency.

The part of the original article which deals with the mobilization of the civil resources of the country merits particular attention, treating, as it does, with a subject in relation to which the literature at present available for military students is small.

Une page de l'histoire militaire belge. Le Siège d'Anvers. The original article is contributed by Capt. Wanty to No. 3 of the *Bulletin;* it contains an interesting account of the blockading operations carried out against Antwerp in 1584-5, by Farnese, the Governor of the Spanish Netherlands ; the city was captured by him in August, 1585.

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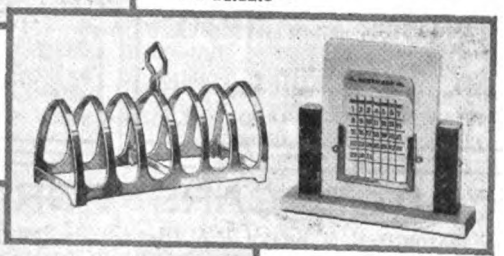

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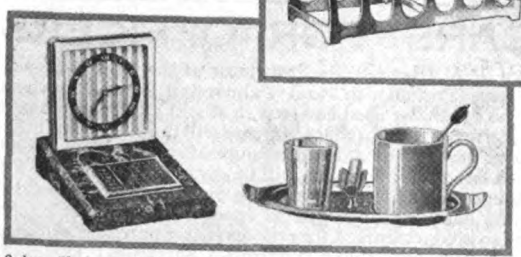

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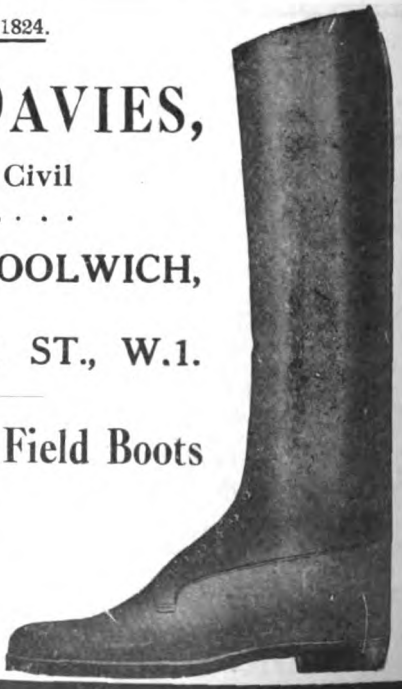

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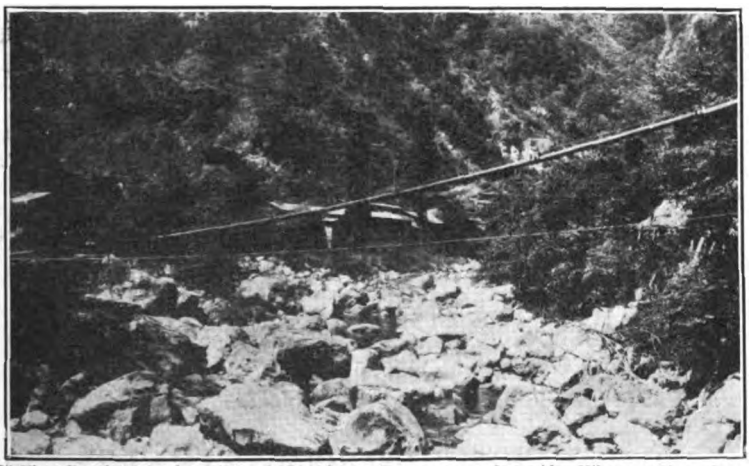

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THE ANGLO-PERSIAN OIL COMPANY, LTD.

A Lecture delivered at the S.M.E., Chatham, on March 6th, 1930, by LIEUT.-COLONEL H. E. MEDLICOTT, D.S.O.

I MUST preface my remarks by asking you to remember that I am not a technician. I propose to deal with the general history of the Anglo-Persian Oil Company from its infancy to the present time, when it has taken its place among the most important commercial undertakings of the world. It is beyond my powers in describing the progress of the Company's activities to enter into a detailed discussion of the minutiæ of refining processes, or to venture into the turbulent and controversial arena of geology and geophysics—these are for the experts and specialists—and so, having made my apology in the first place, I hope that those of you who expected a scientific discussion will still find interest in what I have to say.

The Anglo-Persian Oil Company's concession in Persia was obtained in 1901, by William Knox D'Arcy, and is commonly referred to as the D'Arcy Concession. It gives the Company an exclusive right to search for and exploit petroleum throughout the whole of Persia with the exception of the five northern, or so-called Caspian provinces, Azerbaijan, Mazanderan, Gilan, Astrabad and Khorassan, which were regarded as being in the Russian sphere of influence.

From the earliest days, use has been made of the oil seepages in Persia and Mesopotamia; we know that bitumen was used in cementing the bricks of Ur and in mummifying the royal dead in Egypt, where, on account of the distance it had to be transported, it was a luxury only available to the richest in the land.

There is reason to suppose that the Zoroastrians, those early Persians for whom fire was the symbol of the purity of the all-powerful spirit whom they worshipped, have built their temples round a spot where the inflammable gases from the oil beneath the ground have been ignited by lightning or other natural source.

There are various stories regarding the manner in which D'Arcy's attention was first directed to Persia as a possible field of riches, but there is no doubt that anyone who had travelled at all extensively either in Khuzistan or in the region of Naft Khaneh field could have told him of the numerous seepages.

It does not necessarily stand to reason that the place where the oil comes out of the ground is anywhere near the source of supply; dependent upon the geological formation, the oil might travel almost

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any distance before finding an outlet, and in these days when we know so much more, though by no means all there is to be known, about the structure of that portion of the earth's crust, the presence of a seepage is not necessarily regarded as evidence that there is any prospect of finding oil in commercial quantities in the vicinity.

D'Arcy started drilling in 1903 at Kasri-Shirin, reasonably near the present rich field of Naft Khaneh, where seepages were reported; he had made a considerable fortune in the Broken Hill Mine in Australia and he proceeded to devote most of his capital to the furtherance of his new oil schemes. Drilling is an expensive business at the best of times and, as can be easily understood, the cost per foot drilled varies enormously according to the hardness of the strata to be drilled and the distances over which the machinery has to be transported. No doubt, having regard to the fact that surface indications of oil were plentiful, it was hoped that the reservoir was not at any great depth. The first well drilled at Chia Sourkh, however, reached a depth of over 2,300 feet before oil was struck in anything like useful quantity, and altogether two producing wells were brought in, in January and May, 1904, one of which flowed at the rate of 30 tons a day. The remoteness of the field, some 600 miles from the Persian Gulf, made its proper development both difficult and expensive. Some more accessible and more productive district would have to be found if the venture was to be a success.

In the meantime, the expenses of operation in so remote and undeveloped a country as this part of Persia were becoming appalling to contemplate. When I tell you that the cost of drilling a well in such an isolated position may easily rise to £30, £40 or even £50 per foot, it is not difficult to understand how quickly even the large amount of capital at D'Arcy's disposal was swallowed up in the first few years; £300,000 of his own money was expended and it says a great deal for his pluck that he had not given up altogether when, at the end of 1904, he had nothing to show except two small wells in a remote and inaccessible part of the world.

In the course of this talk, I shall have occasion to mention one or two men to whom Britain should certainly be grateful for the services which they have wrought for her in securing an independent and safe supply of that now so vital commodity, oil. First and foremost in this list must stand William Knox D'Arcy.

When, at the stage I speak of, he was hard pressed for money, he was approached by a German group with a proposal to relieve him of the concession; in the light of subsequent events it was not difficult to appreciate the significance of this move on the part of the nation whose attention was even then concentrated on the project of a Berlin–Baghdad Railway, which would have wrested the trade of a hemisphere from Great Britain. D'Arcy refused the offer of the Germans, forgoing the opportunity of turning his losses into profits,

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although he had naturally gone into the business principally for commercial reasons. It was, indeed, a fortunate decision for Britain.

Even so early in 1904, the problem of converting the Royal Navy to oil fuel had been exercising the minds of those at the Admiralty. The advantages, as regards design and economy and welfare of personnel, were manifold, higher speeds and greater radius of action could be attained, fewer men employed and the fuel could be fed from places remote from the boilers, making it possible for naval architects to effect great improvement in the fighting value of the ships.

Further, an oil-burning fleet could refuel at sea from tanker vessels with far greater facility than could ever be done with coal. Against these advantages was one terrible disadvantage, viz., source of supply. All the coal we needed was at our hand in British mines, secure from any blockade from an enemy. Not so the oil. The world, at that time, depended almost entirely upon the American Continent for its supplies, and requirements on the scale of those of the British Fleet would probably have been unprocurable from any other source, and the width of the Atlantic made it impossible to consider this source as a secure one in every eventuality.

A Committee was appointed, with the Right Hon. E. G. Pretyman as Chairman, to discuss the matter of supplies; on this committee was Sir Boverton Redwood, who knew D'Arcy well and had a high opinion of the importance of the Persian field. Partly as a result of the intervention of this committee, the Burmah Oil Company and Lord Strathcona were induced to come to D'Arcy's assistance, and in 1905 the Concession Syndicate, financed principally by the Burmah Oil Company, was formed at Glasgow to take over the further exploitation of the Persian concession.

This was the first occasion upon which the British Government extended a helping hand to the A.P.O.C. There was to be another more important one, of which I shall have more to say later.

The first step taken towards the search for a new and more prolific area was the removal of the scene of operations from Chiah Sourkh to Marmatain, not far from Ahwaz on the Karun River. Here drilling was recommenced and hopes ran high, since the locality was easily accessible from the Gulf and presented no difficulties. The results, however, were unsatisfactory and a further search became necessary. It is realized now that drilling was not carried deep enough to provide a real test, but at all events the attention of the Syndicate was next directed to a new area in the Bakhtiari Hills, about 145 miles from the head of the Persian Gulf. The story goes that D'Arcy's attention was first drawn to this locality by Monsieur De Morgan, a French archæologist, who had been engaged for many years on excavations in the neighbourhood of Shushtar. He is supposed to have remarked on some occasion to D'Arcy that if surface indications of oil were any guarantee of the presence of

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petroleum in large quantities in the neighbourhood, then there was a spot on the caravan road between Shushtar and Malamir which might be worth looking at.

The spot referred to was a desolate valley called Maidan-i-Naftun, which means the Plain of Oil. This name now applies only to the original small plain where the earliest wells were drilled. As the limits of the field were extended and other localities were included, the name of Masjid-i-Sulaiman was taken to cover the whole area. The name means " Temple of Solomon," and refers to the ancient Zoroastrian ruin, which is a central feature of the district. It had, of course, nothing whatever to do with Solomon, but in common with many other places in Persia has been attributed to him by the local population. I do not know whether any of you have ever seen the country of which I am speaking. You will have an opportunity to judge of its appearance from the film which will be shown after I have finished talking. The strata in these hills have been so twisted and pressed together that the whole landscape presents a most fantastic appearance, with the strata for the most part standing on edge instead of lying flat. Indeed the whole appearance of the country round the oilfields beggars description, and I am reminded of an extract from the diary of a young officer in the Indian Army, who had made the journey to Maidan-i-Naftun. His descriptive powers were perhaps not his strongest point, but having kept an excellent account of his journey until he arrived in the neighbourhood of the oilfields, he evidently felt compelled to continue his notes, and accordingly made the entry " quaint hillocks," a description which by its very inadequacy is almost impressive.

The indication of which De Morgan spoke was a small oil spring which bubbles up in the bed of a salt stream running through the valley. Long before the Anglo-Persian Oil Company came on the scene, the Persian tribesmen had collected the oil by skimming it from the surface by roughly damming the stream. The oil so collected was used for burning purposes or for application to wounds both in man and beast.

I might mention that these oil springs are common enough throughout all the mountain ranges extending from the Caucasus, on the north-west of Persia, to the Indian Frontier on the south-east.

As you may imagine, the task of moving the heavy drilling equipment to the new site of operations was an arduous and expensive one. It would be difficult for anyone visiting the oilfields to-day to realize that the area occupied by that highly modernized community, with its railways, roads, motor-cars and residential and industrial buildings, was less than 25 years ago a howling wilderness, and it would be difficult also to realize what hardships the pioneers were called upon to endure. As everybody knows, the climate of the Persian Gulf region is not a pleasant one, and in the summer, shade-temperatures of 128° are not unusual. Although the oilfields

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are situated some 500 feet or so above sea-level, the gypsum hills which surround them hold the heat to a very marked degree, so that the welcome drop in temperature at sunset, which is a feature of the alluvial plain below, is absent in the case of the oilfields, and in spite of their greater altitude, the summer nights are often more trying than in Abadan, which is practically at sea-level.

The inhabitants at that time were wild nomads, few of whom had ever seen a European before. Organized labour conditions were quite unknown, and although the Persian Government were, according to the terms of the concession, under obligation to give the Company any necessary protection, the isolated position and primitive conditions of the country made the efficacy of any available protective measures very problematical, nor was the authority of local tribal chiefs of the most certain kind.

Drilling proceeded slowly, money vanished rapidly and in May, 1908, the fresh capital provided by the Concession Syndicate was nearly exhausted. At the headquarters of the Syndicate in Glasgow, depression and anxiety reigned, even D'Arcy, whose optimism had carried him through so much to victory, was beginning to flag. Then on May 26th, 1908, oil was struck, and D'Arcy's hopes were realized and vindicated, since the strength of the gusher which wrecked the derrick and nearly killed the drillers when it came in, left little doubt as to the richness of the store that had been tapped.

A year later, in 1909, the Anglo-Persian Oil Company was formed, with a capital of £2,000,000 sterling, which was increased by further issues of debentures and preference shares in 1910 and 1912 to £2,900,000. Lord Strathcona was the first chairman.

It was in 1912 that the liquid fuel problem became even more pressing at the Admiralty. Mr. Winston Churchill was then First Lord and he set up a Royal Commission on Oil Supply, over which Admiral Lord Fisher was asked to preside. I do not propose to trace the steps by which this Committee reached its decision, as Mr. Churchill himself has told the story in his own vigorous and inimitable fashion in the first volume of the *World Crisis*. Suffice it to say that the famous and much discussed Anglo-Persian Oil Agreement was the outcome of Mr. Churchill's action, and now the Government are the owners of the controlling share in oil properties and interests which are at present valued, I am quoting Mr. Churchill, at " scores of millions sterling." Thus was secured for the Navy a sure source of supply completely independent of America, and capable of enormous expansion to meet any demands likely to be made upon it.

This was in 1913. In the interval, the productivity of the oilfield had been amply proved by the striking of a particularly prolific well in 1908. Developments were extended and in the nearby field of Maidan-i-Naftak, a further abundant yield was obtained at a depth of 1,875 feet. Once assured of the supply, the immediate problem was the work of its transport and treatment. A site for a large

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refinery was selected on the Island of Abadan ; launches, barges and stern-wheeler shallow draught vessels were placed on the lower and upper reaches of the Karun River. A short railway was laid to overcome the obstacle of the rapids at Ahwaz, and an up-river terminus was constructed at Dar-i-Khazineh, which means the "Door of the Treasure House." A motor road was constructed from there over the remaining 30 miles to the oilfields, running up through the foothills where previously only a mule track had existed.

To lay a pipe line across the alluvial plain, which runs back for about 150 miles to the foothills, was simple enough, except when the winter rains reduced it to an impassable waste of mud, but from the edge of this plain the hills rise abruptly in superimposed ranges until the high plateau of Persia is reached. To reach the fields two ranges have to be crossed, and at one point the pipe line attains an elevation of 1,300 feet. A mule track wide enough for two mules to walk abreast had to be blasted through the mountains, and each section of pipe, weighing 820 lb., was carried up by four mules, and laid into position. The sections were then screwed together, until some 1,500 tons of pipe had been laid in this manner. This weight, of course, only represents a small fraction of the total amount laid and refers only to the section which traverses the mountain range, a distance of only about 30 miles out of a total of 150 miles. The total length of the present main pipe line which is duplicated and composite represents altogether a length of over 500 miles.

Although the gas pressure in the fields was amply sufficient to force the oil out of the well mouth and into the flow tanks, the oil could not, of course, flow under its own pressure over such altitudes and for such a distance as to take it to the coast. A huge pumping station was constructed at Tembi, at the head of the pipe line ; and other pump houses or "boosting stations" at intervals along the line, while at the other end of the pipe line, the preparations for building Abadan Refinery were in full swing. On October 1st, 1912, the first delivery of refined products was made to local markets, and the capacity of the refinery reached 6,000,000 gallons a month. It was at this stage that the need for further capital became apparent. Though much construction work had been done there remained a great deal to do, and it so happened that the oil industry was passing through one of its bad periods of poor returns. This, coupled with the fact that the Company had only just reached the stage of development necessary for the earning of dividends, would have made it impossible to raise further capital in the open market on favourable terms, and it was therefore decided to seek the necessary financial assistance of the Government, who were at that moment engaged upon the solution of the problem of oil supplies for the Navy, of which I have previously spoken. At this period, the Chairman—Lord Strathcona—was succeeded by Mr., afterwards Sir Charles and now Lord, Greenway, who during the next seven years combined

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the duties of Chairman and sole Managing Director, and in 1917 William Knox D'Arcy, the real founder of the Company, died too soon to see the full flowering of his enterprise.

With the War, the pressure of the work of development in Persia was increased to the greatest possible extent, the capacity of the Refinery at Abadan was doubled, further pipe line was laid down to meet the increased requirements of crude oil, and arrangements were made for the construction of a number of tankers.

Naturally, the importance of these operations was not lost on the enemy powers. One of the first acts of the Turks on the declaration of war was to endeavour to lay mines at the mouth of the Shatt-el-Arab, so as to make access to Abadan impossible by sea. The fortunate and unexpected arrival of the Indian Expeditionary Force, which fought its first action at Sahil, almost opposite Abadan, prevented the carrying out of this design and also a projected shelling of the Refinery. It is significant that the mines were sent across by land from Constantinople some months before the outbreak of war.

The next step was the invasion of Persia from Amara by way of Hawaizah, with the object of cutting the pipe line. The enemy approached within striking distance of Ahwaz, but were unable to dislodge the small British Force holding the right bank of the Karun River. Their emissaries, however, were successful in persuading some of the tribesmen to co-operate by cutting the pipe line above Ahwaz. After the battle of Shaiba, however, the Turks withdrew, closely pursued by the 12th Division under General Gorringe. Order was quickly restored in Southern Persia and the Company was free to carry on its operations, which had now become of vital national importance. All the Turks had succeeded in doing was to hold up work for about four months and cause the loss of 144,000 tons of oil, representing over £400,000. No further trouble was experienced.

Since that time, the record of the Company's operations has been one of continuous and rapid expansion. All through the War years, every nerve was strained to meet the enormous needs of the Mesopotamian Expeditionary Forces for petrol, kerosene and fuel oil, and the ever-increasing demands of the Admiralty. This necessitated constant additions to the Company's plant—additions made exceedingly arduous by the inevitable restrictions and difficulties of the period. Vast quantities of material were required. English foundries and factories were already overwhelmed with war orders, and it was almost impossible to obtain freights for the long voyage to Persia. There was the further difficulty of recruiting the extra European staff made necessary by these developments.

The face of the world has changed much since the date when the first gusher was struck at Maidan-i-Naftun. Everywhere the old order has given place to the new and unfamiliar, and nowhere is the change more apparent than in Persia itself. With the disappearance of the Qajar Dynasty from the throne of Persia, a new movement

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swept across that country. I have said earlier that law and order held but insecure tenure in the south, but that is no longer true. The present Shah, a man of great character and individuality, has succeeded in consolidating the power of his Central Government, so that instead of being a place of lawless tribes and feudal states, Persia is rapidly becoming a modern democracy.

Although the growth of nationalism in any country is bound to be accompanied by a certain amount of feeling against foreigners and foreign undertakings, there is little doubt that the security and prosperity resulting from the development and reorganization of the country's administration outweigh in advantage any inconvenience that may be caused by nationalist feelings. The Persian Government and public realize the great financial and other advantages they derive from the presence of the great oil industry in their country, and though agitators cry out against what they call the stream of liquid gold which is flowing from their country into the pockets of the foreigners, responsible people do not pay much attention to this type of propaganda, and moreover know that they would be quite incapable of carrying on the work themselves. Incidentally, the royalties which the Persian Government obtains from the Oil Company represent the greatest and most secure economic asset the country possesses.

The importance of the oilfields to the British Navy has already been stressed. Their importance to the British Empire is no less vital. Petrol, which has become a human necessity, is used in such vastly growing quantities that all the ingenuity of our chemists has been turned to the problem of increasing the percentage of petrol obtainable from any given quantity of crude oil, with the result that, in the last few years, the proportion of petrol ultimately recoverable per barrel of crude oil has risen from about 11 per cent. in 1909 to about 36·7 per cent. in 1929. I need not stress the point which must leap to the minds of all of you : " How shall this vital supply be kept secure for Britain ? " This question not only applies to the Persian oilfields in the south, but equally to the comparatively undeveloped but exceedingly rich fields of the Khanaqin Oil Company, which lie on the borders of Iraq and Persia, part being in either country, some 150 miles north-east of Baghdad, and also to the vast oil resources of the Mosul area and the rest of Iraq which are exploited by the Iraq Petroleum Company, in which Great Britain has a quarter share. The outlet for the Iraq and Khanaqin fields will, of course, be to the Mediterranean, and no doubt you have seen many references in the papers to the vexed question of the point where the pipe line is to debouch.

In South Persia the Company has three main centres, *i.e.*, the Refinery at Abadan, the pipe line headquarters at Ahwaz and the fields themselves. The Refinery at Abadan is on the Shatt-el-Arab, a confluent of the Tigris and Euphrates, some 50 miles

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above the point where it debouches into the Gulf. This Refinery represents the latest developments in all the processes of refining, with a capacity of about 4,500,000 tons p.a., and is still increasing. To the jetties of this oil port come a continuous stream of tankers to load and carry their cargo to India, Australia and Great Britain. The fleet of the Anglo-Persian Oil Company now numbers 86 vessels of an average tonnage of 9,000 tons, including 6 being built.

Europeans, many of whom have their wives and families with them, are housed in the residential quarter of Abadan, in excellent bungalows built by the Company and standing in gardens which the persistent desire of the Briton for flowers has caused to blossom in what is, I suppose, the most unfavourable soil in the world. The Island of Abadan, some 60 miles in length, is formed by the Shatt-el-Arab on the west side and the Bahmashir on the east, joined at the top by a short channel on which Mohammerah, some 8 miles north of Abadan, is situated. The island itself is completely flat and at its highest point perhaps 10 feet above sea-level. It is practically devoid of vegetation except for a fringe of date palms, and at its southern extreme it degenerates into mud flats which for many miles are covered at high tide or when there is a southerly wind. On this inclement spot, a quagmire in the rains and a burning desert in the summer, this flourishing town has sprung up round the industry which employs some ten thousand Persians, who live on the south side of the Refinery, while the European quarter is to the north. In spite of the natural disadvantages of the place, the Company has succeeded by the introduction of any amount of amenities, such as clubs, swimming pools, squash courts, tennis courts, cinema theatres, football grounds, and even an 18-hole golf course, which can be said certainly to consist of 18 holes and nothing else, in making the lives of the employees very pleasant ones. As I have said, there are gardens around the bungalows, and an astonishing variety of plants can be induced to grow.

From this refinery town runs the pipe line inland towards the fields with watchmen's huts every few miles along it, where pressures, etc., are taken at stated intervals. Upon it also are the boosting stations, of which mention has already been made. These form in themselves a small community of about seven Europeans and a large number of Persians, whose function it is to look after the powerful pumping machinery which maintains the pressure in the pipe lines.

At Ahwaz, some 75 miles from Abadan, there is a centre of considerable importance with a large *sief* or wharf and considerable storehouses for material destined for fields. It is at this point that all material which has come up the River Karun has to be unloaded and carried up a short railway round the rapids, to be reloaded on a shallower draught vessel to complete the journey to D.I.K. Here, too, resides the Governor-General, who is the senior Persian Government official in the Company's area, with whom friendly and close

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contact is maintained. It may be interesting to note here that it is at this point that the southern section of the railway, which is being constructed by the Ulen Company of America, crosses the River Karun on a bridge of steel piers carrying a single line. This section of the railway runs from Dizful to the new Persian port of Bandar-i-Shapur, on the Khor Musa.

This port has a special significance for Persia. When the Perso-Iraq Frontier was delimited, the usual practice of fixing the frontier down the middle of a river was for some reason not followed, and the Iraq Frontier actually begins at low water mark on the Persian side of the Shatt-el-Arab, so that we have the anomaly of the tanker vessels being in Iraq when they are alongside the jetties at Abadan.

The new port is wholly Persian and has the advantage of being situated on a creek of great depth, without a bar which constitutes a serious obstacle to shipping, and above all, in which there is no silting in progress.

The creek in question almost undoubtedly was once upon a time the old mouth of the Karun, before it changed its course and broke through into the Bahmashir and the Shatt-el-Arab.

In the event of the trans-Persian Railway being completed, the new port will play an immense part in the opening up and development of Persia. It is practically the only place on the whole Persian coast where a sheltered anchorage and opportunities for the discharge of cargo to jetties is possible. Even now with the railway only reaching as far as Dizful, its importance is very great and the possibility of its substitution for Abadan as a port of call for a certain number of the Company's oil tankers must not be lost sight of.

But I have digressed. To return to the oil pipe line: we now follow it across the plain till it reaches the foothills and mounts up to cross the Imam Reza range, descending on the other side to the main pumping station at Tembi.

The motor road follows the Karun to a point where a break in the hills formed by one of the tributary streams gave the engineer an opportunity of building the railway and road to fields. On the banks of the river is the Company's wharf and storehouses at the railhead. This is the Dar-i-Khazineh, and here the material which has been brought up the river from Mohammerah and Abadan, trans-shipped to smaller steamers at Ahwaz, is unloaded and taken by lorry or rail to the oilfields.

On the way up by the motor road, one catches a glimpse of the snow-capped Bakhtiari Hills to the north, and I can tell you that when in August one can see the last vanishing traces of the snow, so near-seeming and yet so inaccessible, it makes one's mouth water, with the temperature at about 110° in the shade.

It is a very strange sensation after driving through a fantastic wilderness of gypsum-veined hills, bare of all vegetation but for a month in spring when they are a mass of flowers, to come suddenly

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upon a tarred road, an iron gate set in the buttress of a rocky defile, a uniformed Persian servant of the Company who presents a book for signature, and then to find oneself as the road turns into more open country, in the middle of a thriving modern community, with electric lamp standards along the roads, huge workshops echoing to the clang of machinery, rows of neat bungalows set each in their own garden, fleets of cars and lorries and not one drop of oil to be seen.

Gone are the days of exciting but somewhat dangerous methods which permitted the new well to spout its contents over the countryside until it could be got properly under control, or when the uncontrolled gases, as the night grew cool, inundated the gullies and low-lying spaces, bringing death to the skulking hyenas and jackals, and sometimes, sad to relate, to belated human wanderers. All now proceeds " according to plan, securely and with danger to none."

There was a time when the picturesqueness of the fields was materially added to by the presence of numerous enormous flares ; real " pillars of smoke by day and pillars of fire by night." These represented what was formerly the only method of getting rid of the vast volumes of gas which are always present under pressure together with the oil. This gas in the early days became a very grave menace to the lives of the personnel in the oilfields. It is invisible, heavier than air and very deadly, and it used to collect in valleys and hollows, where it was a lurking menace to any who passed that way. Something had to be done to get rid of it, and it was decided to build great six-foot conduits leading up to several vast burners on the tops of the surrounding hills. These were ignited by shots fired from a Very light pistol, and for years poured their columns of smoke and flame hundreds of feet into the air, giving the place a most infernal aspect by night. Now, however, millions of gallons annually of benzine are extracted from the gas by a new method of compression and absorption, and the number of the flares has consequently dwindled to, I think I am right in saying, about two or three very inferior ones.

About 7,000 Persians are employed in the oilfields and altogether, one would not be far out in estimating in round figures the number of Persians employed by the Company in all its centres at 20,000, which, of course, does not include the enormous number of tradesmen and others who depend indirectly upon the Company for their living.

At the period immediately after the War, it was an accepted practice, almost an axiom, to build a refinery at the nearest possible point to the source of supply. It seemed to the Company, however, that for many reasons it was desirable to create another great refinery in addition to the one at Abadan to serve its British and European trade, and accordingly Llandarcy was built, incidentally providing work for thousands of Britishers. Llandarcy Refinery, like Abadan, represents the last word in the development of all refining processes and has helped to make the port of Swansea one of the most progressive in these Islands.

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THE GERMAN ENGINEER AND PIONEER CORPS.

(INGENIEUR=UND PIONIER=KORPS.)

By COLONEL G. H ADDISON, C.M.G., D.S.O.

PART II.

Reorganization during the Course of the War.

Three separate problems had to be dealt with during the war :—

(*a*) the provision of newly-formed Corps and Divisions with Pioneer units ;

(*b*) increase of the number of Pioneers in every division, so as to improve the ratio of Pioneers to infantry ;

(*c*) creation of additional units to cope with the new weapons and technical methods that grew up with the war.

To a great extent, all three had to be faced simultaneously, and as will become apparent, the claims of (*a*) and (*c*) continually conflicted with those of (*b*), which, in the eyes of the Pioneers, was of first importance. Floods of keen but raw recruits streamed into the depots,* there to be first trained individually, and then kneaded into new units. At the same time the heavy losses in the early battles raised a continual cry for reinforcements ; while scarcely less urgent were the demands of civil industry for tradesmen. Amid these conflicting claims nothing could be done to help the original divisional Pioneers, on whom increasingly heavy calls were made. The shortage was just as bad among the army companies, many of which were tied up in the attack of certain fortresses, notably Maubeuge, Longwy and Antwerp. The remainder were quite insufficient to deal with all the semi-permanent bridging wanted as the advance went on.

Example of Overwork of Field Companies.

A typical case of the strain imposed on divisional companies is given. The 1st (Reserve) Company of the 3rd Pioneers was the only company with the 6th Reserve Division. About 6 p.m., on the 4th October, 1914, after several days of continuous fighting, they reached the River Nethe, over which assault bridges of improvised material were thrown. These had to be launched under heavy fire, and the Pioneers crossed them in company with two battalions of the 35th (Reserve) Infantry Regiment to the assault of Lierre. As soon as

* Lt.-Col. Augustin says that, whereas France had in peace 2·1% of the population with the Colours, Germany only had 1·2% ; a very poor proportion of the possible effectives.

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the southern part of the town had been cleared they repaired the existing road bridges under artillery fire, and then took part in the storming of the northern area. Here the attack was held up by barricades and broken ground. During the night the divisional bridging train came up and the company threw pontoon bridges over the two southern branches of the river, whereby artillery was enabled to advance and deal with the barricades. At 7 a.m. next morning, assault bridges were made south-west of Lierre for a battalion of the 26th (Reserve) Regiment. The infantry hesitated to advance over the water-logged meadows, so the Pioneers led the way, cleared the opposite bank by rifle fire, and then launched the bridges, by which the position was stormed. In Lierre the heavy traffic over the bridges necessitated constant repair work, and an additional bridge was built in the south part of the town over which, in spite of continual damage and interruption by enemy fire, reinforcements of infantry and artillery were able to go forward. By this time the company had worked and fought continuously for over 50 hours, without a single pause; neither rest nor relief was possible.

Beginning of Trench Warfare.

When, after the battle of the Marne, the war gradually took on the appearance of a siege, new demands were quickly made on the Pioneers. The fighting arms were quite unprepared for these conditions and depended more than ever on technical assistance. Fortunately, some of the fortress Pioneer battalions had taken part in extensive siege manœuvres during peace, and the field companies soon learnt the tricks from them. Many divisions improvised infantry Pioneer companies, but this only left the regiments themselves the more helpless and increased their calls for skilled assistance. The first trench mortars and flame-projectors came into use, and were manned by personnel withdrawn from Pioneer units. It is not surprising that the autumn and winter of 1914 passed away without any improvement in the ratio of Pioneers to infantry.

Developments during 1915.

Further delays occurred at the beginning of 1915, when bridging trains had to be raised for the new formations that were created by withdrawing fortress troops from the Eastern Front. Then mine warfare came into prominence, for which fresh companies were continually needed. A new form of Pioneer assault tactics in conjunction with flame-projectors was introduced in the Argonne by Lieut. Beumelberg, after whom it was named,* and this was followed by an increase in, and proper organization of, flame-projector troops. In March, a special "assault" detachment was formed, consisting

* The German official monograph *Argonne* says, "In the rolling-up of enemy trenches, which was later developed as a special method of fighting, Lieut. Beumelberg (Walter), 2/Pi/30, early exhibited an exemplary mastery."

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of headquarters, 2 Pioneer companies, and a gun section with 20 3·7-cm. guns; and at the same time the 3rd Guard Pioneer Battalion was organized as a flame-projector unit, with headquarters, four companies and a workshop detachment. The assault detachment tried out new methods of attack and, at first, made much use of portable shields and body armour; the personnel were employed both as instructors of the infantry, and as the nucleus of specially selected assault parties. At last, in April, sufficient new units became available to provide every division in the field with two field companies. This was only a beginning. The need for field companies on a scale of one per infantry regiment was generally recognized, although an alternative proposal to increase the establishment of existing companies from 250 to 300 men met with some support. Both plans were rudely checked by the scheme of army reorganization, by which all divisions were gradually reduced from four to three regiments; the regiments thus released being grouped into fresh divisions, which again had to be furnished with technical units.

At the beginning of this year, intensive experiments had been carried out with disinfection and breathing apparatus (*Desinfektionsgerät und Luftfläschen*) by two special Pioneer companies under Colonel Peterson; and in April and May, the 35th and 36th Pioneer Regiments, each of two 3-company battalions, were established as gas-warfare troops.

About the same time the first Pioneer park company was formed in the Sixth Army area; eleven more for the other armies following at intervals during the year.

In June, the first detachment of Pioneers, equivalent to about one company, departed for Turkey.

For the Austro-German crossing of the Danube in October, a Pioneer "landing" company, for which an establishment had been prepared in peace, was brought into being, and was provided with special landing equipment based on English experiences.* A Pioneer "ferrying" company was also formed for the rafting operations at Semendria.

During the autumn the increase in enemy air activity required a systematic organization of anti-aircraft troops, and the Pioneers were called on to man the anti-aircraft searchlights; the first detachment, equipped with 90-cm. lights, was assembled in September.

All this time, trench mortar units were in a constant state of reorganization and expansion, and their requirements brought a steady drain on the Pioneer resources.

Complaints as to the recruiting position in Germany, and delays in sending reinforcements, led to a demand for field training depots at the front. At first the War Ministry objected strongly, fearing lest unauthorized units might be formed and Pioneer reserves used

* Presumably at Gallipoli.

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up too quickly. However, in October, permission was granted to establish a Pioneer training depot in the XVI Corps area, where the personality and experience of the Commander (Gen. von Mudra, late Chief of the Eng. and Pi. Corps) provided a guarantee against misuse, and where the conditions in the Argonne offered peculiar facilities for training. Thus the year 1915 did produce a certain measure of improvement in the unsatisfactory position created by inadequate peace establishments; it was, however, no more than a meagre approach to what was really needed.

1916.

During 1916, the process of forming new divisions went on simultaneously with the reduction of four regiments to three within the division. The number of divisions in a corps was increased, and the heavy casualties and need for relief of exhausted divisions had the effect that the divisions in a corps were constantly being changed. This only served to accentuate the difficulties of the Pioneer situation, and to increase the urgency of continuity in technical control. The result was that selected Pioneer officers were gradually detailed by G.H.Q. to take command of all the Pioneer units in divisions, and were given small staffs for the purpose. The normal organization of divisional Pioneers began to be recognized as: headquarters, two field companies, searchlight section, trench mortar company, bridging train. Parks, or other special units attached to the division were put under the Pioneer commander. Some divisions, particularly at Verdun and on the Somme, improvised additional units; for instance, the 56th Division at the Mort'Homme, in July, formed a third field company by taking one section from each of the others, putting the senior subaltern in command; this division had found it necessary to form a mining company from each infantry regiment some time earlier. Even six units were not enough at the height of a battle, and eight companies (field and mining) were employed in mining operations under the Pioneer commander west of Givenchy-en-Gohelle during August. When mine warfare reached its zenith, between 40 and 50 special Pioneer companies had been formed, besides a number of improvised units.

During phases of the Verdun fighting it was found necessary to allot a field company to every battalion, although the infantry were better trained in field works than ever before. In fact, it is said that the infantry-man at this time would rather have been without his rifle than his spade.

The drain on Pioneer reserves continued to be very severe all through this year; for, in addition to the heavy battle losses, trench mortar and flame-projector units were still further added to, and a number of fresh searchlight units formed. Two Pioneer recruit training depots were established behind the Verdun front; also one

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in the Balkan theatre, which was called for not only by the distance, but by the need of allowing reinforcements to become acclimatized.

Other developments during this year were a "Water Transport" (No. 310) Pioneer Company, used for canal traffic in Alsace-Lorraine, under the director of railways; the appointment of an Inspector of Gas regiments; and the inauguration of a Pioneer training establishment at Maubeuge, to which resting battalions were sent for refresher courses, or for special instruction and training in schemes for the break-through.

1917.

The year 1917 was ushered in by an administrative measure that was long overdue. On January 24th, formal approval was given to the establishment of a Pioneer battalion headquarters with every division. In many divisions there were still only one or two field companies;* unfortunately, also, some divisional commanders did not yet know how to make use of the new organization. But, at all events, divisional Pioneers had recovered the tactical unity of which mobilization had deprived them. At the same time, Pioneer staffs with Corps Headquarters were regularized; but the position here remained unsatisfactory, for only one staff officer (a captain) was allowed. Junior officers could not be expected to possess either the authority or the experience that were needed, and during the summer they were replaced by Pioneer lieut.-colonels.

Further developments occurred during the first half of the year. The recruit training depots had proved so successful that they were established behind every army. A Pioneer officers' training school was opened at Maubeuge for the Western Front, and at Kovno for the Eastern. Searchlight detachments were reorganized in consequence of the introduction of a portable electric light, which was so much simpler in use than the delicate oxy-acetylene pattern, that it became possible to hand it over to the fighting arms, only retaining small care and maintenance parties of Pioneers.† A special trench-warfare Pioneer park organization was set up, comprising four battalions, each of three companies, a trench mortar park inspectorate with five companies and a trench mortar instructional detachment. The role of this organization was to administer the vast quantity of trench-warfare weapons in corps and army parks, to inspect and test supplies before delivery from civil firms, and to run the newly-built home depots. Finally, Pioneer units were raised to accompany the so-called "Pasha" expeditionary corps to Asia.

* A British G.H.Q. Intelligence pamphlet dated Jan./17 says: "The number of pioneer companies (exclusive of mining companies) now formed allow of 3 Pioneer field companies for every German division in the field." This was never true, and only approximately so if all available companies had been allotted to divisions, to the complete exclusion of Army Troops, L. of C., etc. The confusion no doubt arose from the German universal ("Einheits-") Pioneer Company system.

† Apparently the small type was taken over by the infantry and the heavy (A/A) by the Air Force, though this is not actually stated.

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The development of the Corps had now reached its zenith. Increasing difficulties in finding reinforcements compelled the War Ministry to issue instructions for retrenchment towards the end of September. The abnormal increases in trench mortar units had drained the Pioneer reserves. L. of C. and home establishments were combed out, all fit men being replaced by those unfit for service. But such measures no longer sufficed. Shortage of men and even more noticeably of horse-flesh brought about a reduction of Pioneer establishments before even the process of building up could be completed. Divisional Pioneer battalions were to remain short of their three companies. "The Nibelungs' hour of doom had struck." Divisional and Corps bridging trains were handed over from Pioneer battalions to ammunition trains and columns, whereby the Pioneer detachments were saved to the benefit of the Pioneer reserve. A little later, 7 Corps and 24 Divisional bridging trains were disbanded, and reductions made in many others; there remained 14 Corps and 30 divisional trains at the disposal of G.H.Q., 22 Corps (5 without horses) and 79 Divisional under Corps and Army Headquarters. The result of these measures was that the equipment, insufficiently cared for by non-technical personnel, steadily deteriorated; and the Pioneers, with restricted opportunities for practice, lost their skill in the technique of bridging; so that, before the 1918 offensive, selected Pioneer units had to be put through intensive courses of training. But, worse still, Pioneer battalions lost the bridging vehicles on which they had been accustomed to depend for the forward transport of trench stores and tools. Night after night drivers and teams had given devoted service under conditions of indescribable difficulty and danger; now they were no longer available.

1918.

The process of retrenchment gradually spread. In February, three divisions had to be disbanded; in June, one; in August, nine; in September, ten; in October, four. The Pioneers of these 27 divisions were retained for the most part as G.H.Q. reserves, only a few companies being used to fill existing gaps in other divisions. The Pioneer staffs were placed in charge of sectors of rear line construction. The total number of Pioneer units was, therefore, not decreased; but, in order to maintain them, the establishment of companies had to be reduced to a nominal 220. Reductions in the infantry could, to some extent, be offset by increases in the number of machine-guns; but it was very difficult to find similar means of replacing Pioneers by machines. No. 421 Pioneer (boring) Company was formed in February, No. 422 (compressed air) Company in April, and No. 423 (mechanical trench-digger) Company in July; but subsequent events put an end to experiments of this kind. There is little more to be said. Three extra gas battalions were formed in 1918, making a total of seven active and one reserve battalions under

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the commander of gas troops. Finally, trench mortar companies were transferred from Pioneer battalions to infantry regiments, but too late to bring any relief to the Pioneers.

In all, during the war, 425 Pioneer companies of various kinds; 176 searchlight sections; 42 divisional, 17 Corps and 11 Army bridging trains; and 4 Pioneer siege trains were newly formed. The number of Pioneers in the German Army rose to roughly 170,000, all ranks, with 8,000 m. length of bridge equipment. Thus the total strength was more than doubled in the course of the war. None the less, the strength within divisions never arrived at what had been asked for, had been shown to be necessary by technical experts before the war, and was proved to be absolutely essential by the War itself. A further 240 companies were required, which means that the total Pioneer strength should have risen to 220,000; *i.e.*, three times the mobilization strength.

Technical Services Not Belonging to the Engineer and Pioneer Corps.

Some mention must be made of certain units which were outside the Pioneer formations and did not draw their personnel from the Pioneer depots; although their work was certainly technical, and ought to be recognized as functions of the Engineer and Pioneer Corps in any future organization.*

The first to be considered are the electrical detachments. Improvised units were formed by some armies in the winter of 1914-15, to take over captured power stations, from which power for workshops and light for billets were distributed about army areas. Later, light was also taken up into the front line. In places, power was used to electrify wire obstacles, but, with the great increase of artillery fire, these were abandoned. Forty-one companies and 76 independent detachments had been formed by March, 1917, when official sanction was given for a regular electrical unit in every army. The commander of this unit belonged to the General Staff of the Army, which led to the interests of the fighting troops being subordinated to those of back areas. In the Seventh Army, sections were attached to divisional and corps Pioneer units, an arrangement that worked well. Personnel of searchlight sections, set free by the reorganization referred to earlier, proved especially apt for this work. With the increasing use of electric power that the future will surely bring, it seems essential that the electrical detachments should be incorporated in the Engineer and Pioneer Corps.

Labour Battalions.—At the beginning of the war, labour detachments of Landsturm were formed into military construction units of various strengths and designations, and distributed among the German fortresses. Numbers of them were soon sent to the front

* It must be understood that in this and similar cases the opinion expressed is that of the German author. See Introduction to Part I in June number *R.E. Journal*.

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for work on rear positions, roads, and billets; and later into the forward zone, where they performed varied and arduous tasks; in fact, within an army area, they came to be regarded as universal constructors, providing for needs that varied from mineral water factories to heavy steel shelters. In the spring of 1915, these mixed formations were reorganized into regular labour battalions, of which there were ultimately 217. When the construction of rear positions was systematically undertaken in 1915 and 1916, directing staffs were formed of officers from all arms, principally staff, Pioneers, and artillery. A number of battalions were allotted also to divisions and were generally placed under the Pioneer commander. The tremendous achievements in field fortification during the latter half of the war owed much to this measure, and to the heroism and devotion of the men of the labour battalions, whose work, carried through without proper officers, organization, or equipment, can never be forgotten by the specialist—the Pioneer. These battalions must have a place in any future scheme of mobilization; their affiliation to the Pioneers will come about, in greater or less degree, of itself.

Railway Units.—Finally, a word about railways.* The permanent peace establishment was three regiments and one Bavarian battalion, the latter always retaining close connection with the Bavarian Pioneer Corps. Every modern means of locomotion and transport was employed in the war. Railways played a part of great tactical as well as administrative importance. Without them, Tannenberg, the Masurian Lakes battle, the breaks-through at Gorlice and on the Isonzo, the campaigns in Serbia and Roumania, and many great battles on the Western Front would all have been impossible. The mobilization scheme provided for 56 construction companies and 4 auxiliary battalions. These proved to be quite inadequate, and very early steps had to be taken to mobilize the personnel of the civil railway and bridge-building industries, whereby a veritable technical transportation army was created. At the end of the war, there were 164 construction companies of various categories, 125 operating companies, 71 labour companies, besides a large number of light railway, ropeway and special units, and 7 armoured trains.

Lessons of the Great War.

Reasons for Shortage of Divisional Pioneers.

If the question is asked, why was it never possible to furnish divisions with the Pioneer units that were recognized as essential, the answer can be given in one word: trench mortars. The Pioneers were the protagonists of this weapon. During siege manœuvres in

* This is not referred to by Lt.-Col. Augustin, but in the historical section of "Der Pionier" there is a brief summary dedicated "To the memory of the German railway troops," which is of interest. As already explained, although originally one with the Pioneers they had been entirely independent since 1875.

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1913, a special Pioneer trench mortar troop had been organized, and the use of mortars in the infantry mobile battle practised; so it naturally fell to the corps to sponsor the weapon in war. But once it had become a going concern, the whole business should have been handed over to the infantry and artillery; and this was, in fact, discussed by the Higher Command from 1916 onwards. The Pioneers themselves were loth to give it up, and the staff feared lest development on sound lines should be checked. Consequently, it was not until the complete exhaustion of Pioneer reserves made it unavoidable that the transfer was ordered; and then it was too late. The organization of trench mortar units underwent many changes. At the period of maximum strength of the army, the trench mortar company comprised three sections; one heavy (4/25 cm.), one medium (8/17 cm.) and one light (6/7·5 cm.), with an establishment of roughly 200. The total strength in the field was thus between 40,000 and 50,000, almost exactly the numbers required to complete every division with three field companies. From first to last, some 200,000 Pioneers and 17,000 mortars passed through these units.

Correct Proportion of Pioneers to Other Arms.

Opinion as to what was the correct proportion of Pioneers with an army had pretty well crystallized by the end of 1916. The Commander of the German First Army, General Fritz von Below, in a paper dealing with the experiences of the Somme Battle, dated January, 1917,* gave his views in full. A little later, the General of Engineers and Pioneers at G.H.Q. issued a detailed scheme, which embraced and amplified Below's proposals; to which he appended a suitable peace establishment. In July, 1918, the War Ministry officially specified Pioneer requirements based on the experiences of the war, as follows: A number of higher staff officers (Generals); with every Army Group, Army, or Army Corps, a Pioneer regimental commander and staff; for every division of three regiments, a Pioneer commander and staff, one battalion of four companies, a field searchlight and anti-aircraft searchlight section, and a divisional bridging train; to every three divisions, one Pioneer battalion as G.H.Q. reserve; to every six divisions, one Pioneer park company, and a Corps bridging train; for each cavalry division, a light Pioneer detachment with light bridging train; as special G.H.Q. troops, one Landing Company, three Gas Regiments, and one Flame-Projector Regiment. The corresponding peace establishment was laid down as: 64 Pioneer regiments (one per division)† comprising 128 battalions, one Gas Pioneer Battalion, one Flame-Projector Pioneer Battalion, an experimental and instructional regiment of two battalions. Except that the Pioneer general proposed a rather larger

* A translation was issued soon afterwards by British G.H.Q. (Intelligence).

† An interesting indication of the size of post-war Army that was then being looked for.

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proportionate peace establishment, there was little difference between his scheme and that of the Ministry. Owing to the result of the war, nothing, of course, came of these proposals. Lieut.-Colonel Augustin sums up by saying that nothing can alter the following conclusions: that a large modern army needs Pioneers in far greater numbers than anything contemplated by Germany before the war; that the peace strength must be large enough to ensure that existing formations do not have to be broken up on mobilization; that units should be organized in the largest possible formations, at least battalions.

Need for a Technical Head of Pioneer Units.

The war proved conclusively the importance of a technical chief of Engineers and Pioneers in the field, and the absolute necessity of regularizing his position at G.H.Q. The Minister of War, von Stein, the Chief of the military cabinet, Freiherr von Lynke, Ludendorff and Hindenburg, all at different times expressed their conviction on these points. But it was only towards the end that official action was taken to improve a state of affairs that had been incredibly bad. Relegated to the 2nd echelon, attached to the Chief of the General Staff, but with no recognized position or authority, the Chief of the Engineer and Pioneer Corps, in the early days of the war, remained in ignorance of the progress of events and with no indication of the intentions of the higher command. Experience proved the need for technical advice and co-ordinating authority, which were gradually made use of by the General Staff, to their own great benefit; in particular may be quoted: Verdun, the "Alberich" (March, 1917) retirement, the 1918 spring offensive especially on the Marne and at Rheims, the construction of the Meuse position, the final Rhine crossing.

Pioneer Stores and Tools.

In 1914, each field company had four tool wagons, carrying wood- and metal-workers' tools for improvised bridging and for demolition work. Three wagons were loaded identically, each carrying the tools of one section, while the fourth held the company reserve and special articles. Various bridging tools and accessories were held in divisional and corps bridging trains; the latter also carried a reserve of explosives. During the war, extra vehicles were added for trench warfare contrivances such as grenades, lights, signals, etc. The original technical vehicles with companies proved unsatisfactory and were replaced by G.S. wagons, otherwise the organization worked well. But care had to be taken not to increase the first line transport of field companies unduly, six tool vehicles per company being regarded as the maximum. Horses for every Pioneer officer in the field proved indispensable for reconnaissance work; equally necessary was a light lorry with every divisional Pioneer battalion H.Q.

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Explosives, Grenades, etc.

The supply of explosives presented difficulties owing to shortage of certain raw materials, and all sorts of makeshifts had to be adopted. The chain of supply in mobile operations was: munitions trains to artillery munition columns; thence to corps bridging trains and so to field companies. In trench warfare, supplies were sent to companies direct from Pioneer parks. Economy in use was insisted on, but for certain operations (*e.g.*, "Alberich") requirements were so large as to necessitate the formation of special explosives columns.

Much difficulty was experienced in producing suitable lights and signal devices, and the end of the war left a number of points undecided. Hand-grenades early assumed importance, as was to be expected from the experiences of the Russo–Japanese War. A small supply of ball (*Kugel*) grenades had been stored in German fortresses, and immediately war broke out the Pioneers began to experiment with new types. The stick (*Stiel*) grenade was considered to be the best produced during the war, and it was copied by all other armies.* It was noteworthy that the British and French preferred the "egg" grenade, designed for defensive use from under cover, while the Germans and Russians favoured the more handy "stick" type, and employed it offensively. Consumption by all arms of the German Army reached the astounding figure of 9,000,000 in one month, a large proportion of which must have been wasted. Every unit carried hand-grenades in its first line transport; supplies were consigned direct from home to Pioneer parks, and thence to the troops. In the great 1918 advance, divisions were followed by light Pioneer columns carrying supplies of grenades, which were replenished from special columns ordered up as necessary by G.H.Q.

Rifle grenades, which were designed by the Engineer Committee in the early days of the war, came into some notice again in 1918; but there were always difficulties in manufacture, mainly as regards raw materials; and there is still much scope for improvement in this weapon, which has particular interest for infantry, cavalry and pioneers. A stick-bomb-thrower became popular, but was unsuited to mobile operations and was superseded by the light trench mortar.

The flame-projector diminished in importance towards the end, the heavy type being immobile, while the light type had a short range and small effect. This weapon, of which the origin dates to pre-war days, has its definite uses as a close-combat accessory. The details of gas-warfare are beyond the scope of this work; its increasing importance is recognized, particularly for artillery, trench mortars, tank units, Pioneers, and above all, the air service.

* Lt.-Col. Augustin's views on these points are open to question.

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Bridging Equipment.

The pontoon equipment proved highly satisfactory and met all requirements. The galvanized steel pontoon was of two types; uni-partite, weighing 1,102 lb.; bi-partite, weighing 661 lb. and 683 lb.; the buoyancy of the complete boats being identical. Corps bridging trains were equipped with the former, one boat and one bay of superstructure being drawn by a six-horse team. In divisional trains, a half pontoon and half a bay of superstructure were carried on four-horse vehicles, which were as mobile as field artillery. The value of the extra mobility was, however, neutralized by the delay caused in joining up the two portions of the boat; the heavier vehicles of the Corps train always came up in time, and, with their complete pontoons and bays, were much to be preferred.* In normal bridge (3½-ton total load, but no lorries) the baulks were gunwale loaded on four boats; in "heavy" bridge (11-ton total load; single line metre-gauge railway) on six boats, with extra baulks and double chessing. A strengthened four-boat bridge to carry 5-ton total (empty 3-ton lorries) could be made by doubling the baulks under wheel tracks. The cavalry had a special steel boat equipment† which was a failure, mainly owing to the high centre of gravity of the vehicles, which caused most of them to break down and be abandoned. A special heavy equipment, which proved entirely successful, was designed for the middle and lower Danube, where heavy seas were liable to be encountered. For the "Pasha" Asiatic Expeditionary Force, a camel transport equipment, composed of light superstructure carried on air-filled rubber floats, proved very successful. There was no assault bridging equipment, and all such had to be improvised. Its importance was emphasized many times, particularly at the crossing of the Nethe and at the battle of the Marne (1918), besides many other occasions (*e.g.*, La Fère, 1918); and French and Belgian experiences confirmed this. The use of such equipment is often preferable to ferrying, and every Pioneer battalion ought to be equipped with 300 m. of bridge; the rubber float type mentioned above would seem suitable.

The requirements of improvised bridging were well catered for by the tools and material carried in special wagons with bridging trains; but the heavier loads, that have since been introduced, demand more heavy timber, heavier pile-drivers, and mechanically-driven circular saws. Motor transport for all bridging equipment is also clearly indicated; the mechanical maintenance would be a normal task for the personnel of the Pioneer electrical detachments.

Although the pontoon equipment met all requirements during the

* The bi-partite boat has apparently been discarded since the War.

† The pontoon was bi-partite, of mild cast steel on a framework of wrought-iron ribs. A cavalry regiment had two 6-horsed wagons, each of which carried two half pontoons, one above the other, and superstructure. See footnote on page 252.

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war, the careful observer cannot ignore the fact that substantial changes are bound to be introduced by the greatly increased weights of modern armament. In considering this, it must not be forgotten that ferrying is much less sensitive to enemy fire than bridging; the crossing of the Marne, in 1918, is a conspicuous example, but for purposes of easy rowing the weight of the pontoon cannot be increased. Again, although motorization of the transport is desirable it should be by a system of tractors, so that in the final tactical advance the vehicles may still be capable of being drawn by horses. And lastly, whatever increases in weight of equipment may become necessary, the available length of bridge, which proved so suitable in the War (35 m. per divisional train, 120 m. per corps train, normal bridge) must not be reduced.

Supply of Technical Stores.

The supply of technical stores, both before and during the War, was directly controlled by the Pioneer Inspectorates, and its smooth working was chiefly due to the fact that experiment, design and provision were all under one head, though the wonderful results that were achieved met with scant recognition at the time. The Engineer Committee, which consisted of three small sections before the War, was employing a staff of over 900 by 1916. General trench-warfare stores were at first all handled by them, but were later taken over by the Ministry of Munitions. This Committee was not unlike the R.E. Board. Anyone could send in inventions or ideas direct to it. It carried out experiments with new devices of every kind and finally settled patterns.

POST-WAR PERIOD.

General.

By the Treaty of Versailles, the Pioneer Corps was limited to seven battalions; *i.e.*, one per infantry division; the battalion to consist of headquarters, two field companies, a bridging column, and a searchlight section. Whether the organization that was mooted in 1918 would have actually been put into force in different circumstances must remain a matter of conjecture. The training of the post-war Pioneer is dealt with in *Der Pionier*, the chief points being summarized in the introduction as follows: the principal feature of Pioneer training is its remarkable many-sidedness. The technical knowledge and skill of officers and men must be such that they may be able to respond to every call for help, wherever or whatever it may be. This implies full knowledge of the tactics and organization of other arms, thorough infantry training being indispensable. But helping others is only one part, and not the most important of the Pioneer's duties; primarily, it is his business to do technical work that is beyond the powers of others. Modern conditions make it

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necessary for all arms to do far more for themselves than in the past; but more than enough is left over for the Pioneers.

Training of Other Ranks.

The recruit is trained during his first six months exactly as an infantry soldier. Pioneer battalions inherit the traditions of their forerunners, especially of the storm-battalions, and they must be fully trained in the tactics of assault troops, understanding the construction, working and handling of all close-combat weapons and devices. Physical training, too, is of outstanding importance to the Pioneers. Besides infantry training, the recruit is practised from the start in the use of entrenching and artizans' tools; the elements of bridging, watermanship, and use of explosives also form part of the early training. At the end of the first period, recruits, still in special squads, take their place in a company, where they learn the handling of the machine-gun and various other duties; they complete their training as mates to older soldiers, the whole period amounting to two years. For special branches and employments (*e.g.*, boatmen, wood and metal-workers, electricians), those most advanced in general training, and best suited, are picked out and given special extra training. The greatest possible number are expected to become specialists in some line; this being particularly necessary for those who aspire to non-commissioned officer rank.

Training of Officers.

The Pioneer officer requires wide knowledge, both tactical and technical; the former so that he may be able to appreciate instinctively the needs of other arms, the latter so as to be in a position to meet those needs. The post-war army makes heavier demands than ever on the Pioneer officer, and very careful selection is, therefore, needed. Aspirants join a Pioneer battalion as volunteers, and do the usual recruit's training, at the same time working methodically for the officer candidate's examination. This examination, which is taken after a school period varying from 1¼ to 3¼ years, takes place annually in Berlin, under instructions from the Pioneer Inspectorate. A successful candidate waits three months and then does the first year's course (actually 10½ months) at the infantry school. After another examination and a few weeks' interval, which is spent doing duty in the Pioneer battalion, and during which he is gazetted *Fähnrich*, he goes to the Pioneer school at Münich for about a year. Theoretical and practical scientific courses are given there as well as advanced military training. Yet another examination must then be passed, after which the candidate returns as *Oberfähnrich* to his unit, where he does duty until his turn arrives for appointment as an officer. The whole training period thus varies from four to six years, depending on the candidate's general educational qualifications.

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Duties of the Post-War Pioneer Officer.

It is impossible in a few words to give any idea of the weight and range of the tasks that lie before the Pioneer officer of to-day. The following notes are concerned with some of the more common :—

River crossings assume more and more importance. Practice is equally necessary with equipment and with improvised material; the latter being especially called for by the tendency of loads to go on increasing in weight.

Explosives of all kinds and their use.

Mine warfare in all its aspects.

Field fortification must always have a prominent place.

Camp construction combined with concealment from aircraft.

Road-making.

Survey has come into some prominence.

Searchlights have produced a whole technique of their own and technicians.

Electric power line work becomes steadily more important, as agriculture, industry generally, and railways are electrified.

The foundations of general *mechanical engineering* are taught at the engineer school, assisted by visits to civil firms.

For employment on *fortress construction* officers have to specialize.

Conclusion.

The circumstances of the German Engineer and Pioneer Corps have always differed in so many respects from those of the Royal Engineers that exact comparisons have little value. None the less, the general course of development during the war in both Corps had many features in common, which will be apparent from the table appended. The story may be not inaptly concluded with one of the many quotations that embellish Lieut.-Colonel Augustin's pages; it is attributed to Frederick the Great.

> " Think of the future and forget the past.
> What is past is done; it is for the future that one has to prepare."

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UNIT.	BRITISH.	GERMAN.
Engineer Park Companies.	Authorized, February, 1915; 1 per Army, and at Base.	First authorized April, 1915. 1 per Army added by end of year.
Electrical and Mechanical Companies, etc.	One formed in September, 1915; 1 per Army authorized Autumn, 1916. Boring Section added to each Company end of 1916. Airlifts added to each Company during 1917.	Improvised in 1915. 1 Electrical Power detachment per Army authorized March, 1917. 1 Boring Company formed February, 1918. 1 Compressed Air Company formed April, 1918. 1 Mechanical Trench-Digger Company formed July, 1918.
Workshop Companies.	Improvised beginning of 1915; 1 per Army authorized June, 1917.	Nil.
Labour Battalions. Training Depots at Front. School of Instruction (Officers).	June, 1915. February, 1917. Towards end of 1916.	Spring, 1915. First in October, 1915. Generally extended to all armies. Towards end of 1916.
Total peace establishment. Total strength after mobilization. Maximum strength during war. Excl. transportation. Maximum strength during war. Incl. „	7,000. 14,000. 250,000. 330,000.	20,000. 120,000 170,000.

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UNIT.	BRITISH.	GERMAN.
Divisional Engineers. { Headquarters.	Attached before war: mobilized with E.F.	Unofficially formed during 1916; formally approved January 24th, 1917.
Divisional Engineers. { Field Companies.	2 per Division on mobilization: all Divisions raised to 3 from beginning of 1915.	1 or 2 per Division on mobilization raised to 2 per Division by middle of 1915. Later new Divisions sometimes only had 1.
Bridging Trains, etc.	60 yd. normal bridge per Division (with Field Companies). 250 yd. normal bridge per Army (in Pontoon Parks). Special steel spans of all sorts from Base Park additional.	35 m. normal bridge per Division (in Divisional bridge train.) 120 m. normal bridge per Corps (in Corps bridge train). Special heavy bridge train additional.
Army Troops Companies.	On scale of 1 per Division in the field, from middle of 1915.	Originally available on scale of roughly 1 per Division. Gradually reduced to 1 per 6 Divisions. No regular scale or allotment.
Searchlights. { Hand.	Small detachments attached to Field Companies at end of 1914, but soon disbanded. Asked for in March, 1915; first unit in the field, April, 1916.	At first 1 section per 2 Divisions. Gradually raised to 1 per Division. First detachment September, 1915. Gradually added to all Divisional S/L. sections.
Searchlights. { Anti-aircraft.		
Mining Companies.	Improvised, December, 1914; first regular Company early 1915. Total of 35 Companies employed in France.	Improvised winter, 1914. 30 Companies raised during 1915. Total employed—between 40 and 50.

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THE ABOR MILITARY AND POLITICAL MISSION, 1912–13.

(*Continued.*)

Compiled from the Diary of the late Capt. P. G. Huddleston, R.E.

2. The Siyom.

Jan. 17. Main advance up right bank of Dihang fixed on. Trenchard arrived by pony about mid-day and gave me my instructions, as we may not meet again for two to three months. To-morrow I walk through to Rotung in one day, 24–6 miles, and the Siyom party, including myself and one surveyor, start on the 23rd, our object being to explore and map all the basin and tributaries of the Siyom River, which joins the Dihang from the west. So I am in luck again!

Jan. 20. Non-stop run to Rotung (exclusive of halts of 5, 10 and 45 minutes), 5 hours, 40 minutes. Not a bit done. Porter and Hore delighted about going to the Siyom and, indeed, we are in luck.

Jan. 24. Yambung, where the main body and headquarters of the great Abor expedition sat for 3 months last year. Got off much better than I expected, about 9 a.m. Got rather excited for a moment, as I thought somebody else was going to bag my coolies. Reached here about 1 p.m. and fished in the Yambung Pool. Our party consists of Capt. Hore (Political officer) in charge of show, Capt. Porter in charge of escort, self, Hamid Gul, surveyor, 1 doctor baboo, 49 rifles, 12 survey khalasies and 65 coolies to carry the kit, also a month's rations from the day we reach Kombong. Carter and 25 sepoys and 285 coolies accompany us as far as Kombong where they return to the main advance up the Dihang. It remains to be seen if the Galongs will carry our loads from Kombong on.

Jan. 25. Camped in jungle on banks of Yambung River. Climb of 1,800 ft. up, and by the time the last coolie reached the top it was like a mud slide. Rained for 2 hours.

Jan. 27. Camp Tadung, a Galong village, visited by white men for the first time, though Dunbar last year, in his dash to Kimbong, passed fairly close. Off 7.15 a.m. to top of pass. Complete mist on top, so started pacing by steps and time and compass bearings, and heights by barometer. By the time we got into the valley below, it cleared and then, climbing a small hill and cutting jungle in two places, got an excellent view of the Sipu valley and the main Subansiri-Siyom divide (11 000–13,000 ft. hills) in the late afternoon.

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Jan. 28. Kombong at last, with its 200 houses "beetling on a crag" as described last year, goodness knows why, there's nothing like a beetle about it, though it is certainly a very fine site and like a small town. Up in the dark, off at 6.30 to hill we had cleared. Only 3,000 ft. Thick mist suddenly started and snows disclosed themselves above a sea of fog and mist; then, worse luck, it came on to rain and the mist came down again; but luckily not before I had got readings with 3 in. from 6 of the peaks, and Hamid Gul had proved some more. Till 1 p.m. occasional peeps through the mist, and amusing the Galongs; then had to come down in disgust. After coming down the hill from Tadung, there is an expanse of sloping fields for the last 3–4 miles all about 1,600 ft. above sea-level, a unique feature for the Himalayas. Streams with low banks, in fact, a most happy valley which it will be delightful to fill in on the world's map, together with the other valleys running up into the snows. Reception by villagers fair. We should have no trouble.

Jan. 29. Went up to the village and to hill above it, where, after clearing, waited till the mist rose about 12.30, disclosing the Siyom with villages. At 2 p.m. dashed back through the village and up another hill about 3 miles off, and back to camp just after dark, really quite a successful day. Hore and Porter in camp diplomatizing with the *gâms* and found it no easy matter. The tribe naturally wants to know why we have come, and is suspicious. No wonder, as it is the first time there is any question of their coming under British suzerainty. One little difficulty is they will at present only take whole rupees and won't look at our 4-anna pieces. In clearing, got the Galongs to work by promising to let them have a look through my binoculars and by firing off my shotgun for them. What a lot of dog-eating shirkers they are! Any excuse for *bakshish*.

Jan. 30. Late rise. No use going off before 10 a.m. as mist did not rise till 11.30. Hore and Porter's diplomacy most successful. Meeting with *gâms* satisfactory. Villagers very pleased with us. Sepoys swapped a pig for a blanket, and chickens for brass buttons are a very ordinary swap. Hore and Hamid Gul to go to Doji and Nomdir, then to Basar on light kit. Porter and I with main force, loads to be carried by Galongs to Along at the junction of the Sipu and Siyom, from where I shall probably do some 2- or 3-day *chukkas*.

Feb. 1. Off 7.30 to Lupum hill, cleared for 2½ hours, got filthy dirty with *ringalls* (small bamboos), had to wash my hands in my cold tea before I could touch my plane-table. Talking of swopping, yesterday I got a flint and steel bag for a box of matches: most of the hill tribes along the Himalayas use these of one pattern or another. The Galongs grow their own tobacco and always have a pipe in their mouths. It would be interesting to know where this tribe originally came from. They must have been here for at least

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200 years, but they say they don't know. The surrounding tribes of Abors look upon the Galongs with great contempt as "dog-eaters" and remain quite separate. From the hill did a most satisfactory day's work for the country ahead.

Feb. 2. Camp at the junction of the Sipu with the Siyom, a junction that we had (all being fishing men) had in our imaginations for some time, though, of course, no *sahib* has ever been near. And we were not wrong either, as after finishing my plane-tabling, and while the camp was being finished, I took out my rod and had two 10-pounders and a 22-pounder in half an hour just before dusk, which could not very well have been better, considering the lowness of both streams. Thanks to Hore's and Porter's diplomacy, the Kombong *gâm* duly produced 121 of his villagers, who by 9 a.m. were carrying our loads through Pankam to Along, which we reached at 1 p.m. They were then paid off at 8 annas each, and to Porter's delight, took the 4-anna pieces. The Kombong *gâm* is evidently a character, as he keeps most unquestioned sway over his villagers and neighbouring villages. The Along folk are fishermen, using long bamboo rods with a line of fibre and a row of nooses and stone. They then float down the Siyom on bamboo rafts and chucking the noose in front of them pull it up. As they float 6–10 of the rafts together, fishing is a very pretty sight. A crowd assembled when I started fishing and they evidently looked on me as a worthy brother angler. To complete a most delightful day, a Galong brought our letters in.

Feb. 4. Found some fishermen with their bamboo boats; they, after some hesitation, agreed to lash 5 together into a raft and take us across. This they did most successfully, 5 at a time in 7 trips in about 1½ hours. The country up the Siyom is now disclosing itself and it is very exciting now that every day opens up new country. The river here splits round many islands and is evidently very low at present. Got two fixings *en route* and one in camp (Jomlo) which we reached at 3 p.m., giving plenty of time to make the usual perimeter and build our *bashas*.

Feb. 5. Set out 7.30. In 7.30. Very nearly bit off a piece more than I could chew in one day, but luck was with me, as the Sirit River is extraordinarily simple, with from 6,000–3,000-ft. slopes running down to a ravine at the bottom, and the villages standing out clear on the slopes. I had a lot of trouble as regards villagers, who are Minyong Abors up this valley, and it would have been better if I had given them more notice and got the headman of the biggest village to come along with me. The Minyongs are most democratic and do nothing without a council in their village town hall, called a *moshop*. The Jomlo *gâm* put in a very late appearance, making me wait for him, but though he sent his brother as a guide, he refused to come himself, and only brought me *apong* as a *salami*. This I

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refused to drink. Mori also gave me a guide but no *gâm* put in an appearance. Same at Jomoy. Plenty of *apong*, but they seemed a most undisciplined crowd, though a big village, and with plenty of young men looking fine in full war kit or *shikar* trim. Road to Rengkhu behind Mori over hill down into the head of the Sirit again and then over the watershed. Wonderful weather when once the mist clears, and snows brilliant at noon till after 2 p.m. Sometimes the whole valley hillsides are blocked out by the *jhum* fires which they are now burning ready for their fresh fields this year. I was asked continuously to-day by single Abors, putting a leaf over their nakedness, to give or sell them cloth. Such is one of the first unnecessary needs of civilization, reminiscent of the Bible though it is.

Feb. 6. Camp opposite Along. The Jomlo villagers seemed desirous of giving the customary presents of eggs and drink, etc., and dissatisfied with their *gâm*. However, I did not take them, and after enduring half an hour's discussion as to the best route, got off. Sent 6 sepoys off with baggage to the Pebu junction and climbed up from 750 to 3,250 ft. up the Rolging fields, but on getting back, suffered a most anxious 15 minutes, as there were no signs of camp. However, by chance, we saw it a mile ahead and I had a few words to say to the *havildar*.

Feb. 7. Along camp. The *havildar* and the Miri *kotoki* (interpreter) made an excellent raft out of three small Abor raftlets we found on the bank, and they ferried us across before 9.30. This bucked me up considerably, as now we can always cross the Siyom, independently of the Abors or Galongs, as long as bamboos are available from the jungle. Completed area east of Along and got back to main camp at 3.30. Galongs well in hand, and ready to do anything for us. Tea, and then to fish with an enormous, greedy crowd watching, which luckily was not disappointed: 3 fish in an hour, 19, 9 and 5 lb., and it would have been more if we had not eaten too long a tea.

Feb. 8. Inked up all day. Filling 250-ft. contours over about 100 sq. miles takes longer than I expected. Fished after tea. Three fish again, 25, 12 and 4 lb. Magnificent sport.

Feb. 10. News that Hore and Hamid Gul are ahead, having evidently worked round as I asked them to. This is great. I am very excited to see what they have turned out.

Feb. 11. Hore and party in. Successful. Hore at Basar was asked to decide in a case of a wife who had been captured by that village from a village of the foot-hills, which are now under our control. Both sides were present, so he asked the woman who promptly said she would not return to her old husband, and was perfectly happy in Basar. So Hore decided they might keep her, but were to pay the deprived husband a heavy fine of 5 cows, 10 pigs, etc., and 15 rupees, which satisfied all except the husband him-

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self. A curious but excellent punishment, like our stocks in the market, was a man in Kombong, who had been condemned by the head *gâm* to wear a heavy wooden log on his leg for 3 years. His leg was through a hole in the middle and he could only get about by supporting it at each step by two ropes at each end, which he held in his hand.

Feb. 12. Hamid Gul inked in his work and I plotted some more points. As it was my last day at this junction, I fished and caught first a 6-pounder, and then, what do you think? A 40-pounder! This beats my 38½-pounder at Pasighat. This was most cheering. Porter is now opening wider and wider the mouths of the Galong *gâms* with some very clever conjuring tricks.

Feb. 13. It was arranged that I should go ahead with half the rifles and we started up the valley of the Siyom, which continues open except for a magnificent crag round the face of which the path wriggles, and from a jutting-out ledge of which a magnificent Abor cane bridge spans the river, here at least 100 yards broad. If for nothing else, these Abors and Galongs ought to be noted for their wonderful cane bridges. After Beni, the Siyom runs through a narrow gorge with several rapids till Wak. Reached camp at 1.30, and leaving the most capable *subadar*, Gang Singh, to mark out and build camp, went off to fish. Apparently my Along reputation had also arrived, as I was accompanied by a crowd of rather sceptical villagers. First few casts near in landed me in a fishing trap, from which an obliging villager detached me with his raft. Changed to a No. 8 spoon, the size of a soup spoon, so as to get right out. Tug. Rush. Bust and a line, minus trace and spoon, came back to me. Villagers interested but disappointed. Spoons being a bit short, changed to a No. 10., size of a gravy spoon. Tug—missed him. A few more throws. Got him! Yes, got him! And in 20 minutes he had been cut on the head by an Abor and was scaling 26 lb. A 15-pounder followed and then some small fish. Abors quite satisfied.

Feb. 14. Could we be having a more fascinating time and experience, especially coming through this more fertile portion of the Siyom? I could not help thinking as one eyed a fishing junction, how comfortable Alexander and his soldiers must have felt when first seeing and marching through richer portions of Persia and Hindustan. Our sepoys are always saying, in their own way, "Top-hole land," and our old head coolie told me how comfortable and rich he could make himself if the Sirkar (Government) would give him a small bit of a hillside in this part.

Feb. 16. Camp at Kambang, at junction of Hirit River. Rained practically continuously all day. In fact, the mist has not risen properly above 4,000-ft. hills since the 9th. Beastly.

Feb. 17. Rain all night and rain all day, till the afternoon, and

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now we pray that a break in the weather may have come. Our coolies went back to-day and brought up some more rations, but only 19 Abors came. Hore writes that the Wak *gâms* are giving trouble also. An awful shock ! Some of the rations have gone bad, having been found fermenting in their bags. So our troubles are beginning, which will add zest to the work. Porter fished in the Hirit junction, but no luck, so I crossed over 200 yards above and in 2 hours caught 7 *boka*, 56 lb. in all. Coolies are most enthusiastic over getting fish nearly every day.

Feb. 18. No high hills clear yet. To our delight, 75 Kambang men went back to Wak to bring the remainder of the stuff and Hore up here, much to the Wak men's disgust. Weather looks more hopeful.

Feb. 19. Waited for guides, who did not turn up, so went off along the river and after much shouting and patience a Galong man came over the Siyom on a raft, and after offering him a cigarette and chatting a bit, suggested he should tie another small raft to his and come over again with his pal and ferry us (15 in all) over. This struck him as a good idea, and back he went, but when the raft was ready a *mithun* turned up which they wanted to take across, so we had to wait till after many struggles they got it into the river. They then condescended to come back and take us across, but it was too late to go up the higher hill, so we went up about 1,000 ft. and then at 2.30 the snows gradually began to disclose themselves and we got by the evening one of those magnificent views that one gets in the Himalayas after a week's rain. Several of the hills that before had only been tipped with snow are now covered much lower down. Every day opens up new valleys, and the survey work is so interesting that I forget to tell the numerous amusing and quaint incidents which occur daily with the savages in the villages around. I don't quite know what constitutes a savage, but each march the tribe —generally a group of 3 to 4 villages—gets more jungly; wants money less but clothes and salt more, and gives louder exclamations of wonder at the things one shows them. They, however, remain just as suspicious of what we want. I am off to-morrow for 6 days to the west, to the foot of the 13,096 range.

Feb. 20. Below Sholing village. Started along left bank of Hirit and reached the bridge opposite Kambang village of 50–60 houses, situated round a wooded knoll alongside a most lovely long pool above which we had to scramble. The path had given way in two places and we had to cut down small trees across the gap to make certain of the coolies getting over safely. Then over a hill and round a corner and we suddenly got a view of part of the head waters of the Hirit and several Karkang tribe villages. The country, with the snow range immediately behind, is much more like the usual Himalayas with the villages high up the hillside and the rivers far down

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in a ravine below. Very nice for surveying quickly. The people also suddenly changed to long-haired creatures dressed in skins. However, to my surprise, they seemed delighted to see me, and I hope we shall have a friendly exchange of presents in the village to-morrow which we could not reach to-day. Weather splendid and Hamid Gul filled in another little bit of this old globe. Villages up here absolutely not known before.

Feb. 21. Half-way up the hill to Sholing, several of the headmen and women met us with drink, eggs and chickens. Yesterday's Kambang guides (of another tribe) were with them and they were evidently *badmashes*, as they said they would not take the salt and cloth as payment, and then again, not the 1s. 8d. in 4-anna pieces. They were, of course, only wanting more, so I gave their salt and cloth to the Sholing villagers, with a bracelet to the old woman who had brought the drink. They were evidently delighted, so it only remained to leave the money in the Kambang men's hands and angrily eye them into silence. As they moved on, we were much amused to see the Galong *kotoki* produce some cloth of his own and do a most profitable deal for the money the men had pretended to disdain. Of course, they see we have more, and, like spoilt children, so to speak, cry if they can't get it. The *kotoki* discovered a lost female cousin among these Karkang Galongs and they were most friendly, giving me more drink and eggs, in return for which I with some ceremony presented him with a pair of cheap scissors, to his intense pride and delight. During this pow-wow, Hamid Gul was sketching in the country from a knoll near, from which, only 2,860 ft., he got a magnificent view of the head waters of the Hirit coming straight down from the 12,000–13,000 snowy range, the top 4,000–5,000 ft. of which are a sheer drop. Weather glorious, the proper sniff of the Himalayas in one's nose. The pleasure in the lovely scenery is rather diminished by a beastly little fly (*damdin*) which swarms in the fields and small jungle, and insists on exchanging, wherever the skin is exposed, its own poison for your blood. The poison is most irritating, waking you up two or three times at night to insist on being scratched.

Feb. 23. Along a nasty path, above the Hirit up to Boru village. Hamid Gul who went ahead had a most lucky escape. His foothold slipping, he fell a few feet, and then, turning several somersaults fell sheer, he says, 50, probably 20–30 ft., into the river below, by the grace of Providence into a deep pool, and not on to rocks. Hence, instead of killing himself, he merely bruised his knee and got a bad ducking. He is an enormous, fair-complexioned Pathan, as strong as a horse, with an insatiable and untiring desire to survey-in more and more country, and makes it a point of honour not to be done by rain or mist or the many daily difficulties that occur, so is first rate for this sort of work. Went over the 4,400 pass at the back. Rain

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all day and had to camp in the rank jungle. Extraordinary how quickly the Gurkha sepoys, khalasies and coolies make you and themselves comfortable.

Feb. 24. A most dreadful day. Rained hard all night and most of the day and then harder. The road could not have been worse. A vertical mud slide up or down or along which we and the poor coolies slithered and cut steps in places. Up 1,000, down 450, up 400, down 600, up 700, down 650. Bridged the Siyom River, up 1,700 and down 1,600 to the Kebung River, below Yangking, which we waded. Leaving 4 rifles with the coolies, took the rest and just finished a footbridge in 2 hours. By the time the coolies came up, they could not have waded safely. Yangking villagers most friendly, brought up firewood and helped in making the camp. Very bad day. Survey work out of the question.

Feb. 25. Left Yangking and, to our delight, struck Hore, at the advance camp at Puitgong junction. Kaying is just ahead, a Minyong village, the *gâm* of which told Hore he thinks the Bori tribe, 3 villages ahead, will fight us. However, we have heard that story before. Hore wishes they would, as we could then insist on help as terms of peace. In Kambang some 100–200 were just going to carry our loads, when a young buck stepped out and harangued them not to. Hore immediately had him and another seized, and, kicking hard, placed in camp under guard. The rest had, meanwhile, bolted, but returned slowly when they did not hear their pal being shot. Result miraculous. They carried our loads without a word, and the haranguer was released next day when all the loads had arrived. Extraordinary how trusting they are. Last year, they would allow themselves to be disarmed of their own will, and be taken into an armed camp, though they had never seen a *sahib* before and had only heard of him by report. It surprises me that women and children don't bolt when we enter a village with our sepoys with fixed bayonets.

Feb. 26. Nothing but glimpses through mist and rain for 4 days now. More and more news that the Boris mean business and that they have been ordered to stop us by the Mimats behind them, who, it now seems, are an outlying tribe of the Tibetans, and, by report, cannibals. Things are really getting interesting.

(*To be continued.*)

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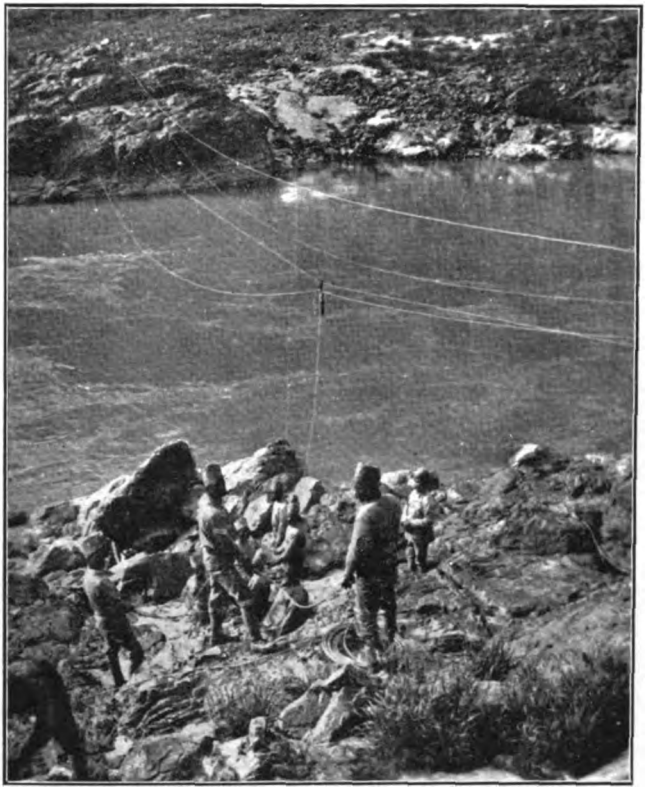
THE ABOR MILITARY AND POLITICAL MISSION, 1913-14.



Potung crossing over Dihang.

A midday halt.

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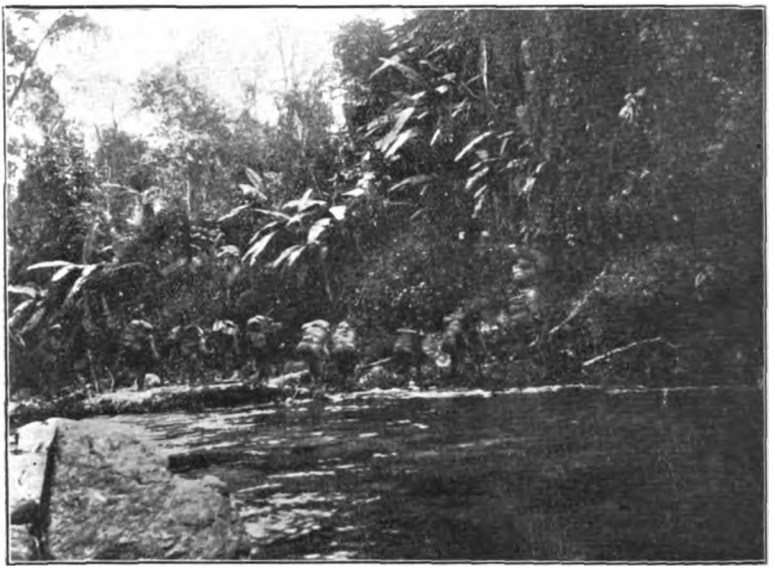
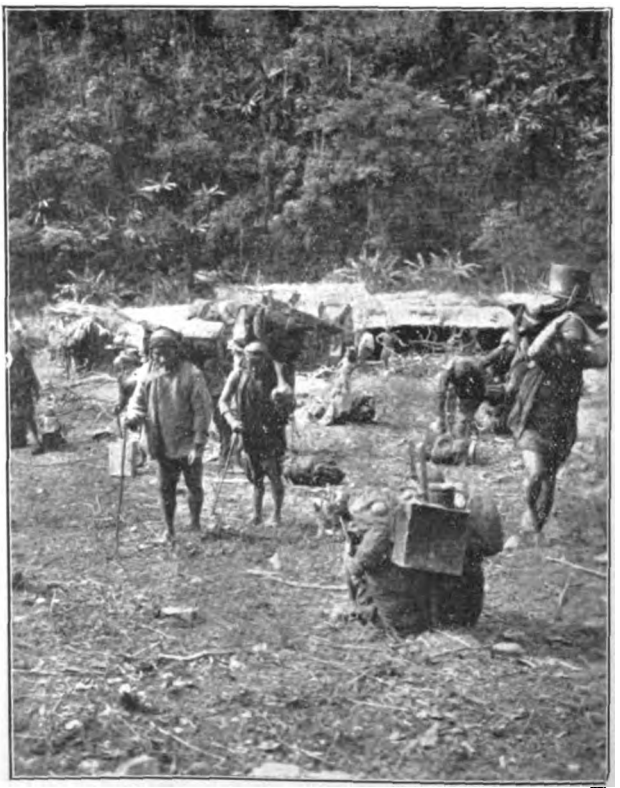


Fallen tree cut down to span Nigong, with coolies going over it.



Coolies starting off with full loads.

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RAILWAY BANK CONSTRUCTION.

By LIEUT.-COLONEL E. ST. G. KIRKE, D.S.O., R.E.

THE time taken to build a railway will, in the absence of large bridges, nearly always depend on the time to complete the earthwork.

When these banks are made by coolie or donkey labour provided with baskets, the time to be taken can readily be calculated from the amount of earthwork to be done, and the strength and nature of the labour party available.

When, however, earth is loaded into railway trucks either by a mechanical digger, or by hand, the best way of unloading it to form a bank needs a good deal of consideration, both from the point of view of cost and also of speed.

The simplest, but not the best way is to lay track on the ground across the hollow which has to be filled, and unload the earth on each side of the trucks as they arrive. The first drawback to this method is that the earth fouls the track unless it is thrown clear by the unloading gangs, and this means extra work for them. The second drawback is that the track has constantly to be lifted and roughly packed as the bank rises. To such an extent is this the case that for every day spent in unloading earth, one more day has to be spent in raising the track.

Another method is to make a bank about five feet high, on one side of the line, and lift the whole track on to it when ready. From this second position of the track the bank can be made over the first position, and raised on it to ten feet. The process can be repeated as often as necessary. While this method is better than the first, it shares with it the disadvantage that the rails used are almost certain to get damaged, and that earth has to be double-shovelled. A good deal of time also is taken in lifting the track from one site to the next.

The best way, therefore, of constructing a bank is to make some sort of gallery from which earth can be tipped clear of the line. The track does not then constantly have to be moved, nor does it run the same risk of injury by uneven sinkage. At the same time the fact that the earth falls from a height tends to consolidate it, particularly in the lower part of the bank.

There are several ways of making such a gallery, depending on its height and the material available. If a crane and the requisite timber and girders are available, the gallery can take the form of a girder bridge on trestle piers, the trestles either remaining in the bank or being pulled out by a crane, when the earth has been unloaded.

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Again, if timber is cheap and plentiful, a timber trestle bridge can be made to span the whole gap. This is the usual method adopted in the N. American continent, and the timber remains in the bank on completion. In either of these two methods the gallery would ordinarily be strong enough to carry a crane or engine.

If, however, the engine is not allowed to run on to the gallery, the

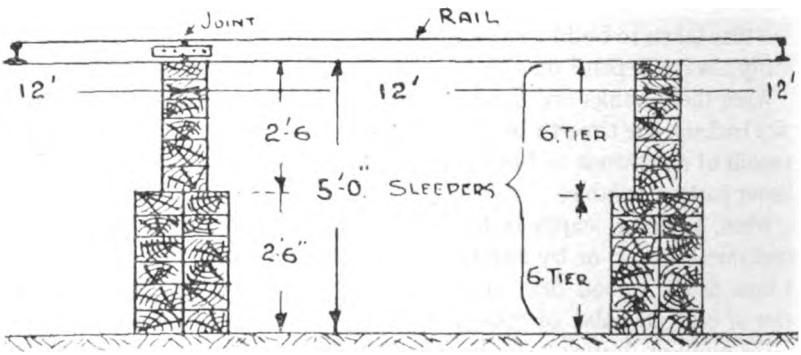

FIG. 1.

equivalent load of ordinary 4-wheel wagons is not above a ton a running foot. This allows 12 tons of earth in a wagon whose tare is 6 tons, and overall length 18 feet.

For banks up to 5 feet in height, a simple way of supporting the track to form a tipping gallery is to lay old sleepers transversely in piers at intervals from 9–12 feet, depending on the length of rail.

With 36-foot rails, a support under each joint and two intermediate piers give spans of 12 feet, over which distance 75-lb. track is able to take 10-ton axle loads without damage to the rails. (Fig. 1.)

The rails, if flat bottomed, can very easily be tied together by gauge ties of a type to hold them out, as well as in, to gauge. These ties may be placed at 10–12 feet intervals. If the rails are bull-headed, ties must be nearer, to make up for the rail's lack of lateral stiffness.

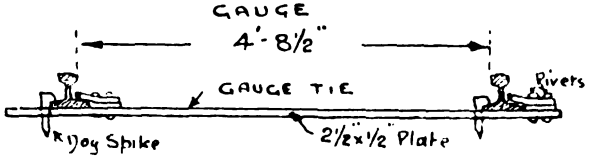

FIG. 2.

When the bank has been made, one end of the sleeper pier must be opened up, and the sleepers pulled out one by one till all are recovered. The holes in the bank are then made good. It may be necessary to double-sleeper the track until the bank gets consolidated by use or rain. Only enough earth need be tipped from the gallery (on the side from which the sleepers will be withdrawn) to support the

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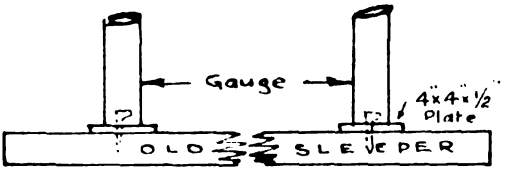
track when they are withdrawn. The remaining earth can be made good afterwards.

If the bank is over 5 feet high, a gallery can very quickly be made from 3-in. tubular scaffolding (*see photograph facing page* 428).

Since the footings have to remain in the bank, they can conveniently be made out of old sleepers, on which must be placed two small bearing-plates 4 in. x 4 in. x ½ in., to prevent the tubes cutting into the sleepers. To keep each plate central to the sleeper and prevent the tube slipping, or getting knocked off it, a hole is drilled in the middle of the plate, and a dogspike half driven through.

Soft ground may necessitate more than one sleeper underneath to distribute the pressure. Each sleeper provides about 7 square feet of bearing area and the load on the piers, if they are spaced to correspond with axle spacings, is the same as the axle load, or 9 tons maximum with ordinary 4-wheeled wagons. One sleeper is ordinarily enough for each pier.



As the tubes are of fixed length, and the load is applied on the top, great care is needed in levelling up the footings, so that the horizontal tubes may not get bent, owing to the tops of the verticals being uneven.

While the first two footings are being levelled, the first two piers can be assembled, each consisting of two upright tubes and one transverse tube, attached to the uprights by couplers.

When ready, they are lifted by hand on to the footings and kept in position by an intermediate longitudinal tube each side, coupled to the uprights about 5 feet above the ground. These intermediates do not appear in the photograph, but serve as platforms for men to stand on when fixing, by " finial " joints, the top of the vertical tubes to the longitudinal members which tie them together.

When the next pair is ready and lifted up into position (by a rope over the previous pier), it can be kept temporarily in place by the intermediate longitudinal members which are slid along through their couplers on the previous pier. The couplers on the last pier but one can be removed when no longer wanted.

During erection the stiffness of the joints prevents side sway, but to prevent any lateral movement while the gallery is under load, side struts are needed. These are formed from longer tubes, coupled to the top longitudinals, and as near as possible to each pier. At their foot, a half sleeper is let into the ground at right angles to the stay tubes and rammed tight. (One of these sleepers can be clearly

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seen above the grass on the left of the photo ; most of the others are hidden by the grass.) Before being coupled up tight to the longitudinal, the tube is used to ram the sleeper hard against the ground. If the piers are canted about 2 in. towards the beginning of the gallery, this will allow for any forward movement which may be caused by braking the train, and the rails moving in their fish plates.

At the far end of the gallery, fore and aft struts, similar to the side stays, may be fixed as a precaution to minimize any jar to the gallery should the train bump into the stop at the end of the track. This end strutting is not really wanted, because the track cannot move forward more than the full stretch of the fish plates, unless the fish bolts shear, but it has a good moral effect on the unloading party.

The track should, of course, be fully fished up and is held to gauge by gauge ties, as already described. It rests on ordinary sleepers laid over the " finial " joints of the piers.

These sleepers can, if necessary, be held in position by spun yarn, or wire, while the rails are being run out. Alternatively, if the side struts are extended slightly above the longitudinals they prevent the sleepers from shifting forward.

When once the load is applied, the underside of these sleepers crushes on to the finial joints. This fixes them firmly in position.

The rails can be run out in pairs along planks, using tubes as rollers. If no planks are handy, the first two rails are run out just over half their length (after which they would tip up) and laid on the transverse sleepers. They then serve as a runway for another pair of rails to be rolled out to their proper position in the track. The process is repeated until the track is laid over the complete gallery.

When all is ready and the earth train arrives, its wagon doors should be unhooked before the rake runs out on to the gallery (where the door catches cannot very easily be knocked up from below).

Emptying each 10-ton truck takes 3 men about 15–20 minutes, unloading both sides, and when the truck is empty no further shovelling is needed, since the earth has fallen quite clear of the track.

The fall of the earth leaves the joints of the tubular scaffolding free to be withdrawn, even when the earth is piled as high as the bottom of the door flaps seen in the photograph. If the track is raised clear of the gallery on jacks, and slewed slightly to one side to allow the uprights to come out, all the tubes can be withdrawn without dismantling the rails.

The vertical tubes are easily pulled out by three men using a rope, but the side stays take seven men, owing to their greater length, and the fact that there is a good weight of earth above them. For this reason it pays to remove alternate side stays before they are completely covered with earth. It is possible that all the side stays can be removed, when enough earth has been unloaded to reach their underside, but this has not yet been proved.

With the piers out of the way, earth can be shovelled into the

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central longitudinal cavity and the track re-laid on ordinary sleepers, doubled until the bank consolidates (the extra sleepers not being spiked). It may be necessary to bring up more earth to increase the bank to full width and correct the side slopes.

With practice 20 men can lay 100 feet of such a gallery 10 feet high in 4 hours, provided that levelling the footings can be done in a reasonable time, and that materials and tools are all ready to hand.

Removing 100 feet of a 10-foot gallery and replacing the track takes 20 practised men about two hours.

A 15-foot gallery is about the highest which can be built without cross-bracing the vertical members to reduce their unsupported length. Alternatively, extra vertical members can be provided.

With higher piers, the upper half of the vertical members must be cross-braced in such a way that the cross-bracing can be removed, or gradually raised, when the earth reaches up to them. If the earth is evenly rammed round the legs it will take the place of the bracing while the upper half of the bank is being tipped.

The only drawback to this method of making a gallery is the first cost of the tubular scaffolding, about £2 a foot run for a 10-ft. bank. When, however, it is remembered that only one old sleeper, two 4 in. x 4 in. x ½ in. mild steel plates, and two dog spikes, are lost at each pier (a matter of two or three shillings), and that the remainder can be used over and over again, the ultimate cost will compare very favourably with any other method of making banks over 5 feet high, in Europe or America. (In Asia or Africa the coolie, or donkey, and basket remain without a rival.) Higher banks than 15 or 20 feet would have to be made in two or more layers.

It is an advantage to make any kind of tipping gallery higher than the top level of the bank, since the full amount of earth can be tipped and dressed to level and slope before the gallery is removed. Any deficiency of soil then noticed can very easily be made good.

Many other uses for tubular scaffolding will at once suggest themselves to the practical engineer, such as staging for water towers, landing stages, piers for bridges, falsework for girder erection, etc.

In connection with the last, Indian railways have used " Sullivan staging," a form of tubular scaffolding, for nearly half a century, and it answers admirably for this purpose. It is, however, heavier than the tubular scaffolding described above, and as the lengths of the diagonal bracing rods are fixed, it has not the same flexibility as the tubular scaffolding, the bracing of which is formed of tubes which can be fixed just as required.

From the tables below it will be seen that these tubes are of little value as beams, their greatest strength being developed when they are used as columns.

The speed with which tubular structures can be assembled should make them particularly useful to R.E. Field Companies.

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PATENT 3-IN. STEEL TUBULAR SCAFFOLDING (WELDLESS TUBE).

(Made by Messrs. Scaffolding (Great Britain) Ltd., Lansdowne Road, S.W.8.)

Outside diam., 3·00 in. Bore, 2·375 in. Area, 2·64 sq. in. Section modulus, 1·6. Radius of gyration, 0·97 in. Tensile strength per sq. in., 30 tons. Weight per ft. run, 9 lb. Weight per coupler, 22 lb. Weight per base, 22 lb. Coupler slips with a load of 3·5 tons.

Length.	Columns.		Beams.	
	Compressive load at which tube would buckle in tons.	Safe load recommended for columns.	Transverse central load at which tube would fail.	Safe load recommended for beams.
6	53·8 tons	13·4 tons	3·2 tons	0·80 tons
7	49·6	12·4	2·7	0·67
8	45·7	11·4	2·4	0·60
9	41·6	10·4	2·1	0·52
10	37·2	9·3	1·9	0·47
11	33·7	8·4	1·7	0·42
12	30·2	7·5	1·6	0·40
13	27·2	6·8	1·5	0·37
14	24·5	6·1	1·4	0·35
15	22·0	5·5	1·3	0·32
16	20·0	5·0	1·2	0·30
17	18·0	4·5	1·1	0·27
18	15·0	3·7	1·0	0·25
19	13·0	3·2	1·0	0·25
20	10·0	2·5	0·9	0·22

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PATENT 2-IN. TUBULAR SCAFFOLDING (WELDLESS TUBE).

Outside diam., 1·90 in. Bore, 1·47 in. Walls, 0·21 in. thick. Area, 1·13 sq. in. Section modulus, 0·42 in. Radius of gyration, 0·60 in. Tensile strength per sq. in., 20 tons. Weight per ft. run, 3·75 lb. Weight per coupler, 5 lb. Weight per base, 5 lb. Coupler slips with a load of 1·75 tons.

Length.	Columns.		Beams.	
	Compressive load at which tube would buckle in columns.	Safe load recommended for columns.	Transverse central load at which tube broke.	Safe load recommended for beams.
	Tons.	Tons.		
6	14·60	3·65	Span Ft. — B.W. Tons.	Tons.
7	12·30	3·08		
8	10·37	2·59	1·0 — 7·50	1·87
9	8·77	2·19	2·0 — 3·75	0·94
10	7·45	1·86	3·0 — 2·50	0·62
11	6·30	1·57	4·0 — 1·90	0·47
12	5·50	1·37	5·0 — 1·50	0·37
13	4·90	1·22	6·0 — 1·25	0·31
14	4·20	1·05	7·0 — 1·07	0·27
15	3·60	0·90	8·0 — 0·94	0·23
16			9·0 — 0·84	0·21
17			10·0 — 0·75	0·19

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R.E. CO-OPERATION WITH CAVALRY.

By MAJOR C. J. S. KING, O.B.E., R.E.

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THE recent appearance of a revised *Cavalry Training Manual* offers a suitable opportunity for a consideration of the subject of R.E. co-operation with cavalry. In the manual the amount of space that is devoted to this subject is small compared with that devoted to the principles of co-operation with other arms, and the reason for this is not far to seek. There is not very much to be said on the general principles, and in a *Cavalry Training Manual* it is not possible or even desirable to enter into any great detail of the subject. Such detail would involve technical descriptions which would be entirely out of place and which are available in *Engineer Manuals* for those who are curious enough to investigate.

From this preliminary remark, it might appear that there is nothing more to be said on the subject, as it is all available in *Engineer Manuals*. This, however, is hardly the case, as the earnest seeker after knowledge would find himself in considerable difficulties if he plunged into all the various engineer publications affecting the subject. The basis of co-operation is knowledge, and it is, therefore, essential that the cavalry officer should know what he may reasonably expect from the R.E. unit with the cavalry division, how much the unit can do, how long it will take to do it, what assistance is required from the cavalry units, and finally, perhaps the most important of all, what the R.E. unit cannot do.

R.E. co-operation with any arm is difficult to practise in peace time, since practically all the work involves either destruction or construction and takes time. The first two cost money and the last may cause an apparent waste in the limited amount of time available for manœuvres; R.E. work is therefore frequently left in the background during manœuvres and false lessons are apt to be learnt.

The Cavalry Division is in a specially unfortunate position, since it does not exist as a formation in peace, and it only functions as such on the rare occasions of Army manœuvres. With the exception of Aldershot, and to a lesser degree at Tidworth, opportunities for co-operation are absent. This article is written with the idea of

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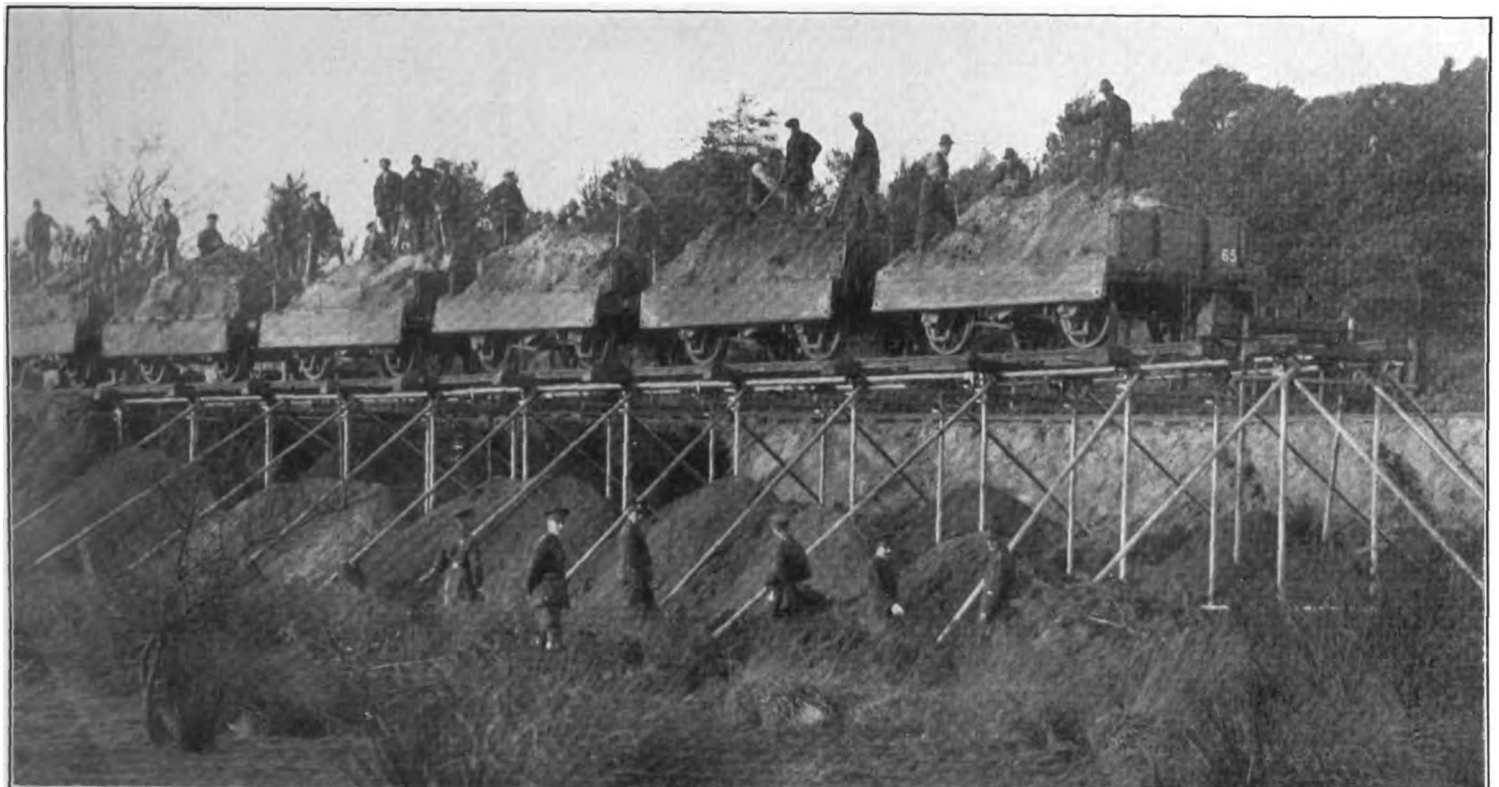
RAILWAY BANK CONSTRUCTION.



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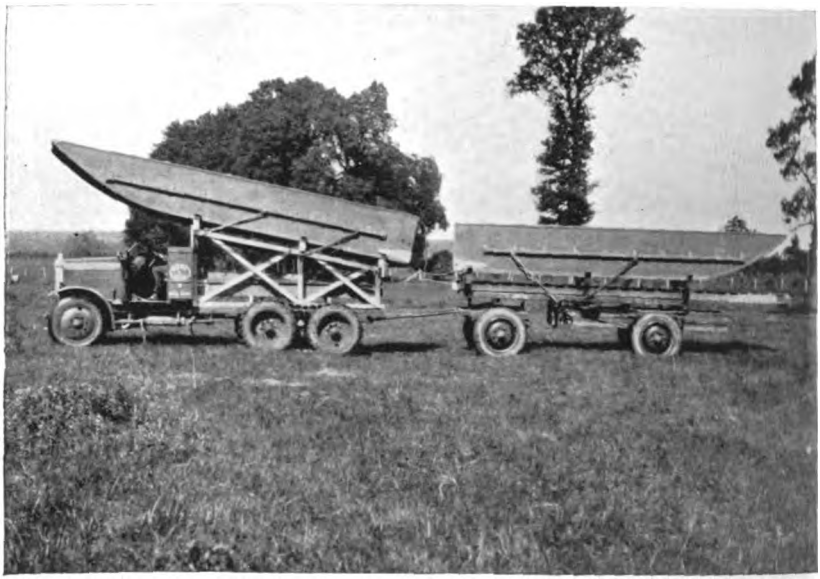

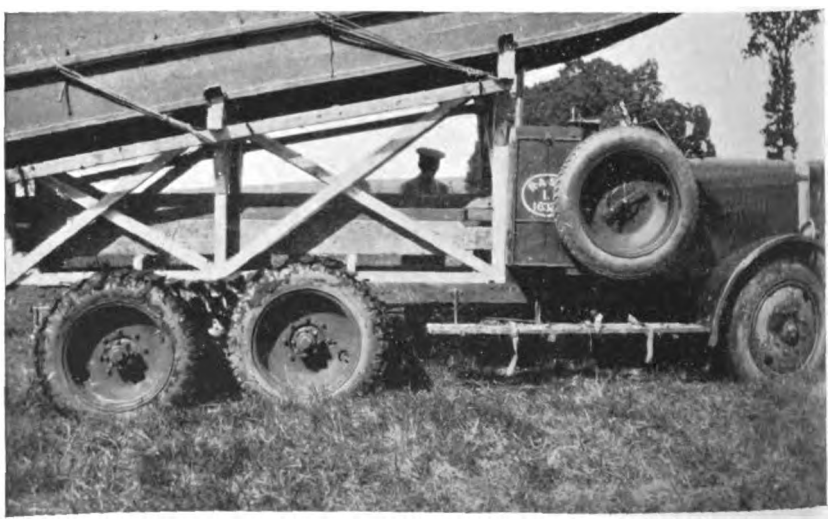

Transport of Pontoon Bridging Equipment.

A complete bay of 21 feet, complete with all the necessary superstructure is carried on the lorry and trailer. For the landing jetty bays, no trailer is required, as all the stores are loaded on the lorry. The lorry is a Guy Medium 6-wheeler.

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setting forth the lessons learnt at those two stations in the past three years for the benefit of those who did not take part in them.

Organization.

The R.E. unit with the Cavalry Division is the Field Squadron R.E. It is now on a mechanized war establishment, but it has not yet been mechanized in peace. This has been imminent for some time, but has not yet been carried out. In the following pages only the mechanized establishments are considered.

In war, the Field Squadron R.E. consists of the following :—

Headquarters.
Headquarter Troop.
3 Field Troops.
1 Bridging Section.

In peace there is one Field Troop less. The unit is carried entirely in mechanical vehicles except that the O.C. is mounted and each Field Troop has a mounted reconnaissance party of 1 officer and 6 other ranks, which as its name implies is purely for reconnaissance and should always accompany the advanced mounted troops as a matter of course.

Each Field Troop can produce a working party of about 36 sappers, and it carries sufficient entrenching tools for its own use only ; it also carries artificers' tools to a very limited extent, but sufficient to enable it to undertake small jobs, provided that the necessary material can be found. 1,120 pounds of explosives are carried.

The Headquarter Troop corresponds to the Field Park Company with a Division. It can produce a working party of about the same size as a Field Troop and it carries entrenching tools and a more complete set of technical tools. It also has a mobile lighting set, for the use of Cavalry Divisional Headquarters.

The Bridging Section is a recent addition to the unit and it carries material for the following bridges (*Cav. Tg.*, Vol. II, Sec. 74) :—

Assault Bridge, 208 feet.
Pontoon equipment (medium bridge), 105 feet.

The use to which this equipment can be put is dealt with in the paragraphs dealing with the actual employment of the unit.

This very brief description of the organization and numbers of the unit is given to emphasize the fact that the Cavalry Division has less R.E. personnel in it than a Division. The proportion is about 1 to 4.

Employment.

Cavalry Training, Vol. II, Sec. 74, gives a list of the tasks that will be carried out by the Field Squadron R.E. These can be con-

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veniently classified under three different heads by arranging them in a slightly different order :—

1. Assisting our own mobility.
    i. Improvement of tracks and roads.
    ii. Clearance of obstacles.
    iii. Fieldworks and bridging.
2. Hampering hostile mobility.
    i. Construction of obstacles, including the use of anti-tank mines.
    ii. Demolitions.
3. Miscellaneous.
    i. Water Supply.
    ii. Washing arrangements.
    iii. Shelters.
    iv. Lighting.

Engineer reconnaissance has been omitted as it is a permanent duty, the necessity for which is present at all times whether any of the special duties mentioned above are being carried out or not. It may be considered as more of a " domestic " duty, since without it, no useful work of any nature can be carried out, and the unit would be entirely useless.

It is now proposed to deal with each of these tasks in turn, and to attempt to give some idea of the amount of work that can be expected from the unit. It is, of course, impossible to give exact figures, since circumstances vary considerably, but the amounts can in many cases be given with sufficient accuracy to give a rough guide.

The Field Squadron has three Field Troops which can work independently, but it must not be assumed that the normal method of employ is to attach one Field Troop to each Cavalry Brigade. The Field Troops must be allotted as required for work, and it would be frequently necessary for the Field Squadron to work as a complete unit.

1. *Assisting Our Own Mobility.*

    i. Improvement of tracks and roads.
    ii. Clearance of obstacles.

These two can be conveniently discussed together, since circumstances vary so much that it is really useless to attempt to give any figures. Remembering the size of the working party of a Field Troop and the fact that it carries sufficient entrenching and cutting tools for its own use only, it is not difficult to visualize the amount of work that can be expected. Any work involving heavy earth work or the removal of large trees is a slow business, and in rapidly moving war-

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fare it is generally quicker to make a detour rather than wait for a path to be cleared in a direct route.

Cavalry Training, Vol. II, Sec. 13–2, mentions the necessity for this type of work when mechanical vehicles are being used, but it also emphasizes the fact that the improvement of roads is a last resource when efforts to find a more suitable route have failed.

iii. Fieldworks and Bridging.

The word " Fieldworks " is a somewhat loose term used in the Royal Engineers to cover any form of work carried out during the collective training period as opposed to individual training in trades. Its meaning here is not clear, though it implies quite rightly that the unit should be ready to undertake any job that it is asked to do. In the matter of bridging, very considerable strides have been made in the last few years, and it is essential that Cavalry officers should know how much has been done and what is being done to improve the situation.

Up till four years ago, the Cavalry Division carried no bridging equipment of any sort. With the advance of mechanization the necessity for bridging becomes more and more urgent, and with the formation of M.G. Squadrons and Armoured Car Regiments it is of supreme importance.

After experiments, the amounts now shown in the manual were authorized, but the arrangement is not in any way final ; experiments are being continued with another and possibly more suitable pattern.

Method of Use of Bridging Equipment.

For rivers up to 105 feet in width, the equipment is sufficient to make :—

(*a*) Two assault bridges each capable of carrying dismounted men.
(*b*) One medium pontoon bridge capable of carrying any load with the Cavalry Division.

For larger rivers, ferrying is necessary, but there is no limit, except time, to the width of the river that can be negotiated. The reason for the arbitrary figure of 105 feet is as follows. It was necessary to put forward some proposal for a definite amount of pontoon equipment. No suggestion could be made which was based on the likely width of the river ; it was therefore proposed to carry sufficient equipment to provide a raft and a landing jetty on each bank and to carry sufficient superstructure to join the whole up into a complete bridge. The attached diagram shows the result, which works out at 105 feet of pontoon bridge. The assault bridge is based on this length. It is perhaps worthy of note that in the last two manœuvres, both in the Aldershot and Southern Commands, no river of more than 105 feet wide was met.

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The crossing of rivers can, therefore, be considered under two heads.

i. Under 105 feet.

Men cross on the assault bridges. Horses can be swum on a rope or can be led across by men walking on the assault bridges placed about 4 yards apart. This has been tried and found quite feasible. Machine-guns can be carried over on the assault bridge, but no vehicles can cross until the pontoon bridge is built. Launching the assault bridge is a matter of minutes.

Erecting the pontoon bridge depends very largely on the difficulties of the site; with two Field Troops available for the work, under average conditions it can be done in half an hour from the time that the equipment arrives on the site of the bridge. The equipment can be handled by one Field Troop, but work would be much slower. A working party up to forty men from a regiment would be of the greatest help in unloading and carrying stores.

This bridge will take any vehicle on the establishment of the Cavalry Division, including armoured cars; it will not take tanks.

ii. Over 105 feet.

The crossing will be a much slower business. It would be possible to use the complete set of assault bridges to produce one bridge 208 feet long, provided the current were not too swift. If this was insufficient, men would have to be ferried over on the pontoons. As at present authorized, two boats can be made out of the equipment. Each boat will carry 24 fighting men and would be rowed by 8 sappers with a coxswain. The fighting men sit facing outwards with their feet on the handrail and jump ashore as soon as they reach shallow water. The operation is easy and quick, as the boats are easily manageable in even a quick current.

These boats can be ready for use in ten minutes after the arrival of the equipment on site, but, of course, the use of the boats for ferrying men delays the use of the equipment for ferrying over the vehicles.

It is possible to make up small rafts capable of carrying two men from the assault bridge floats. No paddles or oars are carried for this, but it has been found that ordinary shovels are quite effective, and that the two men can get across a river with a current of three knots in a reasonable time. From the equipment carried, 16 rafts can be made up.

Using all possible means, therefore, 80 men could attempt the first crossing at one time.

For ferrying vehicles a landing bay has to be erected on each bank, and the vehicles taken over on a raft, which can be worked on a wire rope as a flying bridge or pulled backwards and forwards by a rope or, as a last resource, rowed.

As a result of many trials, it has been found that the first vehicle can be got across in about one hour and a half from the time the

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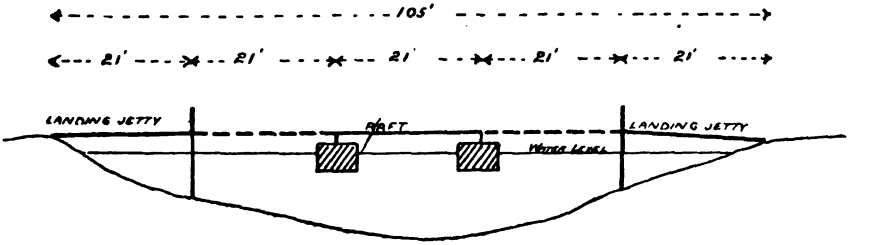
equipment arrives. The time taken per vehicle after this depends largely on the skill of the drivers coming on and off the raft, but may be taken as about 10 minutes per vehicle for a river 100 yards wide.

If the pontoons are being used to carry men, a certain amount of preliminary work can be done on the landing bays; the time for the first vehicle after the pontoon had finished carrying men would be about one hour.

The raft can only carry one light 6-wheeler at a time owing to limitations of space. Surplus men and stores can travel on the raft at the same time.

DIAGRAM SHEWING PONTOON BRIDGING EQUIPMENT
— IN THE CAVALRY DIVISION —



The dotted lines show the superstructure carried to make the complete 105' of bridge.

This equipment has not yet been supplied to the unit, and it has therefore not yet had a fair trial on manœuvres. A certain amount of equipment approximating to this and carried on M.T. was used last year by a Field Troop with the 2nd Cavalry Brigade, and valuable lessons were learnt, but more experience is required before a final decision on the various difficulties can be given.

The operation of forcing a crossing of a river is undoubtedly one that is likely to fall to the lot of the Cavalry Division owing to its mobility. The river may be only lightly held, but even so it is a tactical operation, and failure to carry out the operation quickly will lead to stronger opposition and the necessity for a far more elaborate preparation. This operation is dealt with at some length in *Engineer Training*, Vol. II, but in no other manual. Some ten pages are devoted to it, and a study of these is strongly recommended.

If we consider the phases of an operation in which the Cavalry Division has been ordered to seize and hold a river line pending the arrival of the main body, we can imagine that the two opposing armies

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are approaching each other, and that the one who gets the river line will have a big advantage. The Cavalry Division is therefore sent on to seize it ; it finds that it is held and that all the bridges have been destroyed. If it sits down and waits, the opposition will become stronger, and it is, therefore, decided to force the crossing. It is a difficult operation and involves the closest co-operation.

The first necessity is information. The mounted reconnaissance party of a Field Troop must be with the leading squadron, the Troop Leader with the Squadron Commander and one sapper with each of the patrols which are sent out. The importance of the reports of these sappers cannot be overestimated. They must send back information to their Troop Leader on the following points :—

i. Possibility or otherwise of using assault bridge.

ii. The width of the river.

To obtain this information, it will be necessary for the patrol leader to assist in every possible way, since the information may be difficult to obtain.

As soon as the Troop Leader has got in the reports from all the patrols, it will probably be as well for him to reconnoitre the most promising one or two with the Squadron Commander and come to an agreement with him as to the suitability of the site from a tactical as well as technical point of view.

It must be remembered that the assault bridge is intended to be used by the cavalry themselves ; it is not a technical operation, though R.E. supervision and assistance would be given by the reconnaissance party ; the equipment is obtained from the Field Squadron.

It is, therefore, the job of the Squadron Commander to organize the launching of the bridge or bridges and the covering and assault party. *Infantry Training*, Vol. II, deals with this part of the operation in some detail, and a study of the sections is recommended.

Apart from this general assistance, the Field Troop Leader has a most important duty, and that is to ensure that the bridgehead resulting from the crossings made on the assault bridges shall cover a suitable site for the erection of the pontoon bridge. This is likely to be a matter of some difficulty, and the Squadron Commander, with the Field Troop Leader, will have to consider the requirements before deciding on the site for his assault bridges. A good approach on both sides is the chief point to consider, and generally the most difficult thing to find.

As soon as the bridgehead is formed, the Brigade Commander can order up the pontoon equipment and the bridge can be built.

In the light of our present limited experience, the following appear to be the chief difficulties :—

i. Organization of crossing on assault bridge.

A large number of men are required, and it is difficult to get them up quickly. It is suggested that a definite regiment should be made

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responsible for the operation, and this unit should be earmarked for this operation and for nothing else. An assault bridge requires, roughly, one man per three feet for carrying, so that to deal with the amount actually carried in the Cavalry Division, some 70 men are required. When the covering party, assault parties and horseholders are taken out, very little would be left from two sabre squadrons.

ii. The difficulty of getting the assault bridge equipment up quickly. It is carried in two light 6-wheelers and it must be kept as far up as possible, particularly in closed country. It is considered that it should be handed over to the unit chosen for the operation before the operation starts, instead of moving with the Field Squadron.

iii. The difficulty of getting up the pontoon equipment when required.

This is far more formidable than the previous difficulty, as the equipment is exceedingly bulky and Commanders are unwilling to have such unwieldy and very visible loads too far up in the column. The point needs very careful consideration, since it is obvious that no other vehicles can cross the river till the bridge vehicles have come up. (A photo showing the loaded vehicle of bridge equipment is given. Six such units are required for the Divisional Bridging equipment.)

It is impossible in a general article to deal exhaustively with all the various problems that arise, but the foregoing will serve as an introduction to the subject, and may perhaps arouse the attention of cavalry officers to the importance of the matter. Very considerable attention was paid to this matter in the Mechanized Force at Tidworth, and with the advent of Mechanized Regiments it becomes equally important for cavalry formations.

This year, experiments have been tried with lighter pontoons which may speed up the crossing of the light 6-wheelers. The lighter equipment will not carry armoured cars, and it will be for consideration whether the gain in speed will be sufficient to warrant the transport of the lighter equipment in addition to that required for armoured cars. It is undoubtedly essential that the Cavalry Division should have a bridging equipment which will carry all vehicles which form part of its establishment.

As a purely personal opinion, it is perhaps doubtful whether any very great increase in speed is essential. The assault bridge can be launched in a very few minutes, but no real test has been carried out to find how long it would take a squadron from the time of its arrival at the river to launch the assault bridge and to be formed up on the other side ready to move off. The disorganization resulting from swimming horses is considerable. Is this operation going to be so rapid that a delay of an hour for the building of the bridge to carry the machine-gun lorries is going to delay the advance to any appreciable extent ?

Machine-guns may be necessary to form the bridgehead, but they

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can be carried across and the bridgehead need not be so large that it affords absolute immunity for the building of the pontoon bridge.

2. *Hampering Hostile Mobility.*

i. Construction of obstacles, including the use of anti-tank mines.

It is an old axiom that obstacles are useless unless they are under fire, but it is one that is apt to be lost sight of. The expression "blocking a road" is one that is frequently heard on manœuvres, but as it can seldom be carried out in practice, the difficulties are perhaps not appreciated as fully as they might be, and the problem is worth a more detailed analysis.

Firstly, where should a road be blocked? It is obviously little use blocking it in the open. The enemy can go round the obstacle with very little delay. The block must be made at a defile through which the enemy *must* pass. This limits the choice very considerably, and in most cases reduces it to bridges. In a country which has many roads or, in very open country it is difficult to find a spot, apart from a bridge, the blocking of which would seriously hamper the movements of the enemy. In a mountainous country, conditions are different, but roads in such countries are actually defiles from one end to the other.

Secondly, how should it be blocked? We are limited to blocking those essential points which the enemy must pass. If they are blocked and left unguarded the enemy would certainly be delayed while he removed the block, but this delay would be slight. It is therefore necessary to defend the blocks. We therefore want a block which will force the enemy to emerge from his A.F.V. to remove the block. The defenders can then fire at them with some hope of success.

The problem, therefore, reduces itself to the blocking of these defiles which are actually defended. Of the elementary forms such as cutting down trees or blocking the road with wagons, little need be said. Cutting down trees is a fairly slow business, and the trees must be in the right place. It is not feasible to move a large tree once it is felled without cutting it up. A tree of three feet in diameter would take a couple of hours to fell. Explosives may do the work quicker, but it is difficult to ensure that the tree will fall where it is required. Finally, trees do not grow on bridges. These methods are therefore improvisations and must be treated on their merits.

What is needed is some certain form which will enable a bridge to be blocked and defended against A.F.V.s. If we consider a cavalry formation holding a river crossing pending the arrival of our main forces, the backbone of the defence will be the machine-guns holding the points of crossing. These are powerless against an A.F.V. and they must be provided with some weapon to stop this form of attack. An anti-tank gun is, of course, one solution, but this is a substitution rather than an accessory to the machine-gun. The anti-tank mine

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provides a quick solution provided it is available quickly and in sufficient quantities.

Anti-tank mines can be considered in two ways.

i. For minefields. This requires a very large amount of transport and mines and is outside our province at present.

ii. For road blocks. Mines have to be laid practically touching, and it requires one mine per foot of width of road. Twenty mines will block all ordinary roads, and if this number were available immediately for each section of machine-guns, the section could take on the defence of a bridge against all comers with some hope of success. If these mines were all carried in the Field Squadron, there would be little hope of getting them distributed in time. It is, therefore, considered essential that machine-gun lorries should carry 20 mines for each pair of machine-guns. Their weight would be about 200 pounds. A reserve would be carried in the Field Squadron, which could be used to assist any specially difficult points.

Their use involves no technical knowledge. The tops are screwed off and the mines placed in a row on the road. It is not even necessary to bury them, though it is preferable to do so. To ensure that they are effective against armoured cars, an angle iron picket is laid along the top.

Another point for consideration is the collection of the mines when the force moves on. It would be very difficult for the Field Squadron to distribute mines, but it would be impossible for that unit to collect them. The danger of leaving a well-hidden group of mines on some defile on our main line of advance is obvious, but the danger is real.

This suggestion rather removes the anti-tank mine from the sphere of R.E. co-operation. It overloads the regiment with another gadget, but in spite of these disadvantages it is considered that it is the only sound solution, and a recommendation to that effect was submitted last year.

ii. Demolitions.

Each Troop carries 1,120 pounds of guncotton. The amount carried in the rear echelons is still under consideration, but its supply will be on the same lines as S.A.A. This bald statement of fact is of little use to the cavalry officer, who wants to know how many bridges can be demolished, and how long it will take. This information is exceedingly difficult to give since bridges vary, but a rough generalization can be given which may be of some assistance; it must, however, be taken as a very rough guide only.

Bridges may be classified in many ways, but for the purposes of demolition they may conveniently be considered as follows:—

i. All forms of steel girder bridges.

These are the easiest and quickest to demolish, and it may be taken that a Field Troop can demolish any of them in a couple of hours, however big. They are not commonly used for road bridges

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in this country, though they are more common abroad. They are, of course, common on railways.

ii. Masonry and brick bridges.

These are the most common road bridges, and are more difficult to demolish. *Cavalry Training*, Vol. II, Sec. 82–6, lays down that demolitions which would interfere with the withdrawal will not be carried out till all vehicles have been withdrawn. This adds a further difficulty. The normal method of demolishing a bridge of this nature is to dig a trench down in the roadway as far as the arch and to lay the charge there. This will obviously interfere with the use of the bridge and cannot be permitted. It would be necessary, therefore, to drill holes from underneath into the arch. With our present equipment this is an exceedingly slow business, and would take many hours. The introduction of a pneumatic drill is under consideration and if authorized will cut the time down from hours to minutes.

It is difficult, therefore, to give a working estimate of time, but even if the trench across the road is allowed it may be taken that little can be done under four hours ; one Field Troop could work on four medium-sized bridges at once, and it would carry sufficient explosive for about six bridges of this nature.

A further classification may be useful when considering demolitions.

i. Very low bridges. Such bridges exist over the Avon round Bulford. It is waste of time blowing up such bridges, as the *débris* of the bridges would make it quite possible for tanks and 6-wheelers to cross.

ii. Ordinary road bridges up to 30-foot span. These are exceedingly common, and this type of bridge is considered a medium bridge in the paragraph above giving the amount of work that a Field Troop can do.

iii. Modern bridges over new arterial roads. These are becoming larger and heavier, while the use of reinforced concrete introduces many new problems, which up to the present have not been fully investigated. From the point of view of the cavalry officer it is safe to say that he should not expect their demolition unless 24 hours are available for the work.

In considering demolitions generally, the one point which requires most thought is the question of the timing of the actual demolition. *Cavalry Training*, Vol. II, Sec. 76–3, is quite clear on the point, but the instructions are apt to be overlooked, and on manœuvres most certainly are. It is considered that in important circumstances—and most occasions are important—a paragraph should be inserted in orders naming the officer to whom responsibility is delegated.

3. *Miscellaneous.*

In rapidly moving warfare, little can be done in the way of shelters or washing arrangements. The Field Squadron carries an electric

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lighting set for the use of Divisional Headquarters ; it can be started in a few minutes, but the fixing of the wiring and lights may take an hour or more, depending on the number of lights required.

Water supply is a more important consideration. At present each Field Troop carries one lift-and-force pump, while every unit carries sufficient troughs for its own use. This pump is insufficient and a power-driven pump is under consideration. If authorized, it will be sufficiently big to deal with the water supply of a Cavalry Brigade. Scattered units will have to look after themselves, but the provision of a suitable water point for a concentrated brigade will not present any difficulties provided the water is available, except, perhaps, in the collection of the troughs. This will have to be done under Brigade arrangements, but special attention will have to be paid to their re-distribution when the Brigade moves off.

Raids.

Cavalry Training, Vol. II, Sec. 9, deals with the use of Cavalry on raids, and it is curious to find that Engineers are not mentioned as " normally " forming part of the force. Raids are undertaken with the object of destroying men and material. The destruction of material is essentially an operation for Royal Engineers, and one that requires a considerable amount of organization and preparation. The guiding principle is that a special detachment of Royal Engineers should be earmarked for the purpose of the destruction, and should not be used for any other purpose. If, for example, a bridge has to be built over a river on the way, a separate detachment should be detailed for this purpose. If this is not done the work of destruction will be disorganized and will most certainly fail.

A timely demolition of a bridge in the withdrawal may give the raiding party an opportunity to get clear ; this could be conveniently carried out by leaving a detachment to prepare the demolition during the progress of the raid.

Conclusion.

At the risk of being wearisome, emphasis is again laid on the fact that the advent of mechanization has increased the importance of R.E. work for the Cavalry Division. The whole tendency to-day is to increase our mobility and at the same time to attempt to decrease the mobility of the enemy. These were—intentionally—taken as the two main divisions of R.E. work. The matter is only now beginning to receive the serious attention it deserves, and the problem is far from being solved. It is necessary to ascertain what the problems really are and to experiment continually with existing equipment to find out its defects. Such experiments must be carried out under conditions as real as possible, *i.e.*, on manœuvres. Greater knowledge of each other's requirements and difficulties are required, in other words, closer co-operation.

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MAP PROJECTIONS WITHOUT TEARS.

By CAPTAIN J. C. T. WILLIS, R.E.

THE subject of map projections is one which has caused a good deal of alarm in the minds of many R.E. officers, and it is hoped that this brief introduction, shorn of all formulæ, will assist in clearing away some of its terrors. It is admittedly a case of the blind attempting to lead the blind, but in the kingdom of the blind, the one-eyed is king.

A map projection is any systematic way of representing the meridians and parallels of the earth on a flat sheet of paper.

No map can be a perfect representation of the earth's surface, because a map is flat and the earth is round. That is to say that, although you can wrap paper round a cylinder or a cone, so that it is a perfect fit, you cannot wrap it round a sphere without creasing it. Similarly, you cannot stick a penny stamp on an orange.

A perfect representation of the earth's surface implies that :—

(*a*) All areas on the map would maintain their correct size relative to the corresponding areas on the earth.

(*b*) Shapes on the earth should be represented by exactly similar shapes on the map.

(*c*) Azimuths on the map should correspond exactly with azimuths on the earth.

(*d*) The shortest distance between two points on the sphere (a great circle) should be represented by a straight line on the map,

and, of course, if these four conditions were fulfilled, it follows that :—

(*e*) The scale of the map should be the same in all parts of it.

No one projection can produce all these desired results, so various classes of projections have been invented which aim at securing one or more of these requirements at the expense of the others ; or which strike a sort of golden mean between them all. The special purpose for which a map is required should therefore be considered and the most suitable projection chosen.

In selecting a projection a most important point to be considered is the ease with which it may be constructed, and the simplicity or otherwise of calculating distances, bearings, etc., upon it. No one, least of all the soldier, wishes to be involved needlessly in obscure mathematics.

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Projections may be considered in the following groups.

(1) A projection which shows *areas* correctly and leaves other details to take care of themselves is known as an equal area projection and is obviously of more value to statisticians than to soldiers.

Note.—Mercator's projection (Fig. 1) is a good example of a projection which is *not* equal area : on this projection Greenland appears larger than South America and England is nearly half the size of India.

(2) A projection which shows the shapes correctly, over small areas, though the scale for different portions of the map will vary, is known as an *orthomorphic* or *conformal* projection. It will be seen that if the shapes are kept correct, bearings over relatively small distances will also be the same on the map and on the earth. It is for this reason that an orthomorphic is especially suitable for artillery purposes. In fact, it was the need for increased accuracy of artillery fire which made the soldier realize that all projections were not equally suitable for him, with the result that orthomorphic projections came into prominence during the late War, and remain the most suitable type of projection for all tactical purposes.

Since an orthomorphic projection shows shapes correctly, it follows that meridians and parallels, which intersect at right angles on the earth's surface, must also intersect at right angles on the map.

(3) A projection which maintains the correct direction of azimuth lines radiating from a central point is known as an azimuthal projection and will obviously be of value for wireless stations, radio direction finding, navigation, etc.

We will now consider a few of the more important projections, the reasons for their existence, and what errors we may expect to find in them.

1. The Simple Conic.

This projection is produced by considering a cone, with its axis on the polar axis, tangent to the earth at a given parallel (see Fig. 2). The features of the earth are developed along the radii of the earth outwards towards the cone, which is then opened out along one meridian to form a map. This projection will obviously give a true scale along the parallel at which it touches the earth. Elsewhere it is distorted, this distortion increasing with the distance from the tangent parallel.

The cone, instead of being tangent to the earth, can be made to cut the earth (see Fig. 3), in which case there is no distortion along the two parallels of contact, and at the north and south extremities of the projection less distortion is involved by this method than by the simple tangent cone. This projection in its simple form is little used.

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A conical projection can be converted into either an equal area projection or an orthomorphic projection by a simple mathematical adjustment, as will briefly be shown.

In any conical projection the parallels (with the exception of the standard parallels) cannot be true to scale, they are either expanded or contracted. We can, therefore, by adjusting the spacing of the parallels along the central meridian, alter the properties of the projection.

If we *decrease* the distances apart of the parallels where their scale is exaggerated, and *increase* those distances where the scale is contracted, it follows that we shall obtain a projection in which areas are true to Nature, but shapes will be distorted; in fact, an equal area projection.

In the same way, to obtain an orthomorphic projection we must ensure that the scale along parallels and meridians is the same at each point. This means that where the scale of the parallel has been expanded, the distance apart of the parallels must also be increased, and conversely, where the scale of the parallels is contracted, the distance apart of those parallels must also be contracted. By this means *shapes* are kept correct and the projection becomes orthomorphic.

2. LAMBERT'S CONICAL ORTHOMORPHIC.

In this case a cone is assumed either to touch the earth at one parallel or to cut it at two parallels. The positions of the other parallels are found, not by developing them outwards along the radii of the earth, but by a mathematical computation which has the effect of spacing out the parallels along the meridians in such a way that the projection becomes conformal. As in all conical projections, the parallels are arcs of concentric circles and the meridians are straight lines which would meet at the centre of all these circles.

The parallels and meridians intersect at right angles. The two parallels where the cone cuts the sphere are called the two standard parallels. Along these parallels the scale is correct; elsewhere, the scale distortion increases with the distance from the nearer standard parallel. (See Fig. 4.)

This projection can be extended indefinitely in an east and west direction and, being orthomorphic, is very suitable for military purposes.

3. CASSINI-SOLDNER OR RECTANGULAR SPHEROIDAL PROJECTION.

In this projection we must assume a central meridian, and some definite point on this meridian as origin. Further, we must assume great circles passing through each point in the field and intersecting the central meridian at right angles. The distance of any point from

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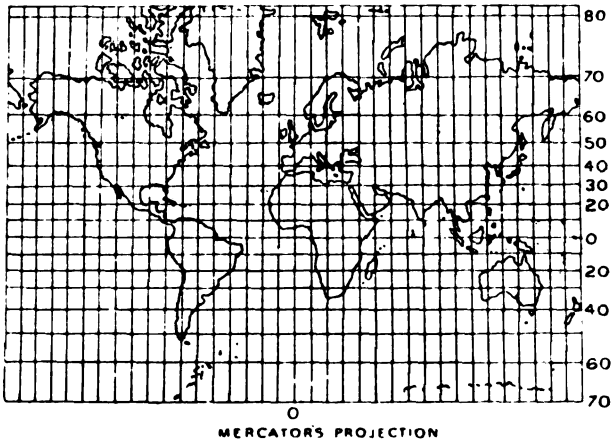

MERCATOR'S PROJECTION

Fig. 1.

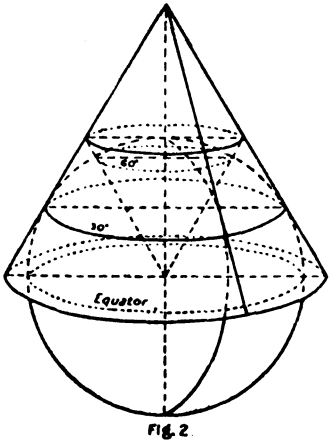

Fig. 2

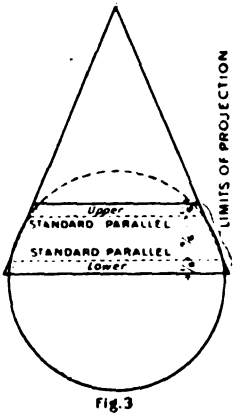

Fig. 3

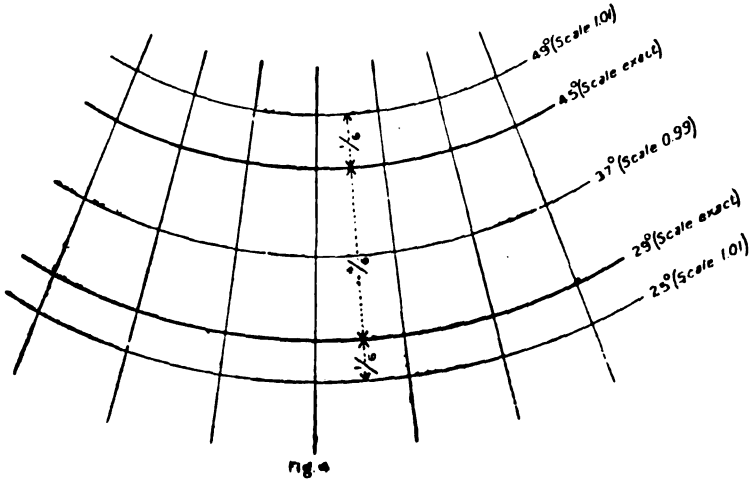

Fig. 4

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the central meridian, measured along the great circle, is taken as the eastings of that point. While the distance (along the meridian) from the point of intersection of this great circle and the selected origin is taken as the northings of that point. (See Fig. 5.) The eastings and northings are then plotted as plane rectangular co-ordinates.

The defect of this projection is that eastings on the map are measured parallel with each other, whereas on the earth they converge as they depart from the central meridian. An inspection of Fig. 5 will make this clear.

Let us suppose that P_1 and Q_1 have the same northings $= x_1$; and P_2 and Q_2 have the same northings $= x_2$. And also that P_1 and P_2 have the same eastings $= y_1$; and Q_1 and Q_2 have the same eastings $= y_2$.

Now the difference between the northings of P_1 and P_2 is the same as the difference between the northings of Q_1 and Q_2. But clearly on the earth $Q_1 Q_2$ is shorter than $P_1 P_2$.

The Cassini projection makes $Q_1 Q_2$ equal to $P_1 P_2$ and also equal to $M_1 M_2$. This is obviously incorrect for all points which do not actually lie on the central meridian.

It is thus seen that the northings in this projection are exaggerated. The eastings, however, are but little affected. They are not absolutely correct, because on the map the lines $M_1 Q_1$ and $M_2 Q_2$ are straightened out and become parallel.

From this it will be clear that though distances in an east and west direction will remain nearly true to scale, distances in a north and south direction will be distorted. Thus the errors in Cassini are most marked in a north and south direction.

Cassini represents a sort of golden mean between equal area and orthomorphic projections and is widely employed. It is used by the Ordnance Survey for the 6-inch, 1-inch, $\frac{1}{2}$-inch and $\frac{1}{4}$-inch maps of England. The scale error on this projection is 1/1000 at a distance of 177 miles from the origin.

4. TRANSVERSE MERCATOR OR GAUSS-CONFORMAL.

It may be recalled that small circles parallel to the equator are known as *Parallels of Latitude*, and that small circles parallel to a given meridian are known as "*Sub-Meridians*."

In the ordinary Mercator projection, as used by the sailor, the projected distances between the parallels of latitude are increased as one goes further north or south of the equator, see Fig. 1: whereas on the earth the spacing of the parallels is, of course, exactly equal.

In the transverse Mercator, a central meridian is selected and the sub-meridians are spaced at distances which are successively greater as one goes farther east or west of this central meridian. One

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therefore speaks of the Gauss-Conformal as being a Mercator projection turned through 90°, hence it is called the transverse Mercator.

The distortion of northings in this projection will be exactly the same as in the Cassini projection, but in the transverse Mercator the eastings (which we have shown in Cassini to be nearly correct) are deliberately distorted to the same extent as the northings. This causes the spacing out of the sub-meridians already mentioned.

But since both eastings and northings have been enlarged (locally) in the same ratio, the projection becomes orthomorphic.

As in Cassini the scale error exists only in northings, while in transverse Mercator the same error has been introduced into the eastings as well as the northings, it follows that the error of *area* in the transverse Mercator is double that in Cassini. The orthomorphic quality in this projection has thus been obtained by a considerable sacrifice of equivalence of area.

This projection, thanks to its being orthomorphic, is of great value to soldiers and, since it is capable of being extended indefinitely in a north and south direction, has been used for maps of Egypt, the China Coast, etc.

5. The Polyconic Projection.

In this projection a series of cones is assumed, each having its apex on the earth's axis prolonged, and each tangent to parallels on the surface of the earth. (See Fig. 6.)

In America, where this projection is largely used, all parallels are thus made true to scale and are spaced at their true distances along the central meridian.

The other meridians are curves which cut the parallels at their true distances measured along each parallel.

The meridians and parallels do not, therefore, intersect at right angles, hence the projection cannot be orthomorphic.

An inspection of Fig. 7, which shows the various segments of the map "unrolled" will make it clear that the projection can be extended in a north and south direction, but that distortion increases with the departure from the central meridian.

This projection is much used in the U.S.A., and a modified form of it has been adopted for the international map of the world, scale 1/1,000,000.

A *Rectangular Polyconic* is formed by spacing the meridians at their correct spherical distances on *one* parallel only (possibly the equator), and making the meridians passing through this parallel cut all other parallels at right angles. The rectangular polyconic is largely used for making small scale maps, 1/2" or 1/5", and is sometimes known as the "War Office" projection.

In constructing this projection it is usual to consider each map

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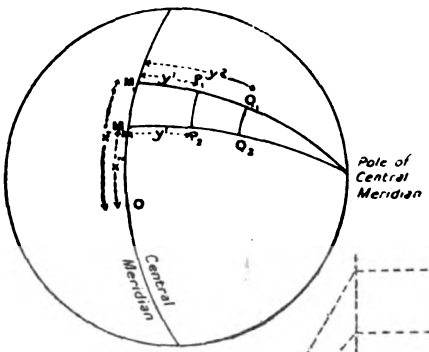

Fig. 5

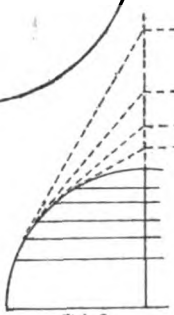

Fig 6

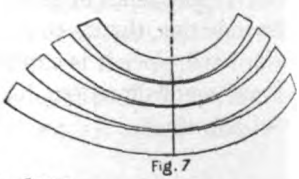

Fig. 7

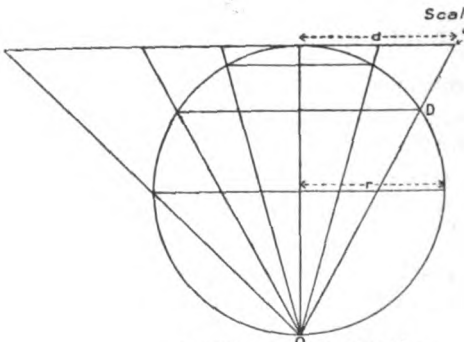

Fig. 8. Stereographic Projection

Fig. 9. Stereographic projection

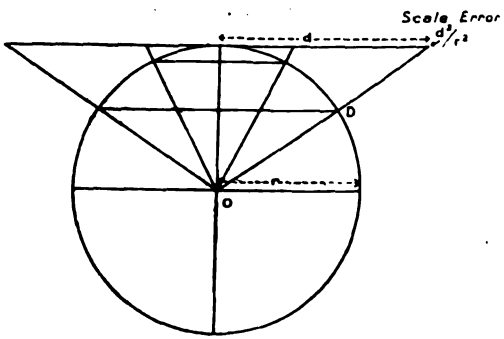

Fig. 10 Gnomic Projection.

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sheet separately, adopting a central meridian for each sheet and plotting the positions of intersection of parallels and meridians from it.

Sheets on this projection, so formed, cannot be joined accurately as the outer meridians of each sheet are curved inwards towards the central meridian, though in actual practice a few sheets can be made to fit by squeezing.

This projection is neither equal area nor orthomorphic, but represents a mean between the two. It is suitable for a zone running north and south but should not be extended in an east and west direction.

We have now considered in detail :—

1. An orthomorphic projection suitable for an east and west zone. (Lambert.)
2. An orthomorphic projection suitable for a north and south zone. (Transverse Mercator.)
3. A " golden mean " projection for small areas. (Cassini.)
4. The polyconic projection, and its cousin the rectangular polyconic.

Some other projections which may be encountered are :—

(*a*) *The Bonne*, an equal area projection much used by the French, but of little interest for military purposes. It is, however, used for 1-inch maps of Ireland and Scotland. It is a development from the simple conical projection.

(*b*) *The Stereographic* (see Fig. 8) in which the surface of the earth is projected on to a tangent plane from a point on the earth's surface immediately opposite the point of tangency. On this projection all circles, whether great circles or not, are shown as circles on the map (see Fig. 9). This is an orthomorphic projection and can be used for islands, or for the polar regions.

(*c*) *The Gnomonic Projection.* In this projection the surface of the earth is projected on to a tangent plane along radii drawn from the centre of the earth. (Fig. 10.) All great circles —that is the shortest distance between two points on the earth's surface, become straight lines on the map. It is thus of great value to sailors for " great circle " sailing. This projection is neither equal area nor orthomorphic. Its scale error is perhaps its chief defect, though the angular errors remote from the origin are also great.

(*d*) *Azimuthal Projections.* This is a group of projections which aims at maintaining correct azimuths radiating from some central point and would be used for radio direction finding and similar purposes. It will be seen that both the foregoing projections, stereoscopic and gnomonic, fall into this class.

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An azimuthal projection would be constructed for use at a wireless station, in which the position of the station was taken as the centre of the projection, and from which all lines would radiate at their true azimuths on the earth's surface.

(*e*) *Mercator's Projection.* (Fig. 1.) This is an orthomorphic projection on to a cylinder in which the latitude scale is distorted to fall into line with the stretching in longitude which is caused by developing the surface of the earth on to a cylinder. (See remarks on transverse Mercator.) In this a loxodrome, or line of constant bearing, becomes a straight line on the map. This quality makes it invaluable for navigation purposes. Nearly all charts are drawn on this projection.

ERRORS IN PROJECTIONS.

(1) *Bearings.*

In most forms of projection the error of bearing round a point varies with the direction of the bearing from that point. In orthomorphic projections there is no error of bearing.

(2) *Scale.*

In the case of meridional projections like the transverse Mercator, the maximum scale error is $y^2/2r^2$ (approx.) where y is the distance from the central meridian and r is the radius of the earth.

In longitudinal projections, like Lambert's, the maximum scale error is $x^2/2r^2$ (approx.) where x is the distance from the central parallel. These figures may be taken to apply to all projections in ordinary use.

In azimuthal projections, the maximum scale error is ordinarily $d^2/4r^2$ where d is the radial distance from the point of tangency. But in the gnomonic projection the maximum scale error is four times this, *i.e.*, d^2/r^2.

These figures may be taken as giving, approximately, the errors in scale, due to the projection, likely to be encountered and, taken in conjunction with the permissible error of the map, will serve to indicate the limits to which the projection may safely be extended.

This scale error may, however, be halved by a simple adjustment which does not in any way affect the bearing.

Let us consider the case of a longitudinal projection with a central parallel, and let X be the scale error on the bounding parallel, north or south of this central parallel. Now it is possible to select two parallels, one on each side of the central parallel along which the scale error is the same, and, by introducing a reduction factor, make the scale correct upon them. These standard parallels will then be so spaced that the maximum error becomes X/2, negative at the central parallel and positive at the bounding parallels.

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Exactly the same procedure can be adopted in the case of meridional projections. Here two standard sub-meridians are selected and the scale error on them is reduced to zero, giving a negative error on the central meridian and a positive error on the bounding sub-meridians, equal to half the amount that the error would have been, had the central meridian been made the standard.

This can be illustrated graphically by imagining that the cone or cylinder on which the projection is developed is made to cut the sphere along two standard parallels (or meridians) instead of being tangential to it. (Compare Figs. 1 and 2.)

This correction is applied to every linear quantity over the field of the map and is sometimes known as the scale factor. It is often incorporated in the tables from which the map is constructed, so that one need not worry further about it.

Limits of Projection.

For the purposes of surveyors, as distinct from mapmakers, the width or depth of a projection must be limited. A scale error of 1/2000 represents a directional error of about 1·5 minutes, which is approaching the limit of accuracy required for artillery purposes.

Accordingly, for a longitudinal projection based on a central parallel, the depth of the zone between the two bounding parallels ought not to exceed 250 miles, *i.e.*, 125 miles north or south of the central parallel.

Similarly, the width of a meridional belt also should not exceed 250 miles; in an azimuthal projection, the circumference which bounds the area around the point of tangency should not be more than 175 miles distant from this point.

If standard parallels and sub-meridians are introduced, the distance from the central parallel or meridian can be increased to 175 miles; in other words, the zone may be 350 miles deep or wide. In the same way that standard sub-meridians and parallels are introduced into other projections, a standard circle of zero scale error may be used in the stereographic projection and the distance from the centre at which this projection can safely be used may then be increased to 250 miles.

The Effect of the Ellipticity of the Earth.

So far we have considered the earth to be a true sphere, but in reality it is an ellipsoid; that is to say that the radius of the curvature of the earth along a meridian and the radius of curvature at right angles to the meridian will vary with the change in latitude.

In general, projections which do not demand any great accuracy in use, such as the gnomonic, are still used in conjunction with a sphere,

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whereas surveyors who require all possible accuracy must consider projections as developed from an ellipsoid.

The difference in actual working between the sphere and the ellipsoid lies in the increased difficulty of computing distances and bearings on a shape which is not a true sphere.

Thoughtful mathematicians have recorded for us the formula by which these distances may be calculated, and, with a ready sympathy for our shortcomings, have drawn up tables for use with most of the common projections. These tables provide values, for given latitudes, of the various functions of the radius of the earth and the radius of curvature perpendicular to the meridian.

THE GRID ON A PROJECTION.

It is worth considering shortly the inter-relation of a grid with a projection.

A grid is a system of true squares on the surface of a map. The map is either built up on this grid, or the grid is superimposed on the map.

The objects of the grid are, briefly :—

(1) To enable map references to be given.
(2) To evaluate the effects of paper distortion.
(3) To provide a standard of reference for bearings, on parallel lines, independent of the convergence of the meridians.
(4) To enable distances and bearings between points to be computed easily and accurately in the field.

To fulfil these objects it will be clear that the grid must be built up of true squares on the map and that each square must be of a given and constant length of side.

The position of the grid is computed from the geographical values of the trigonometrical points and the points themselves are tied as regards their positions by the projection selected.

But it must be remembered that, since each grid square is of a given length of side, as soon as a grid appears upon a map a "fixed scale" element is introduced.

As long as the scale of the map remains constant within the limits of accuracy laid down, the map can be gridded with advantage. The addition of a grid at once shows up the scale error, and in any map where the scale error is appreciable the grid is valueless.

These few notes are only intended to be an introduction to projections as they affect the soldier. For fuller information reference must be made to some of the many books on the subject.

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A SUBALTERN IN THE INDIAN MUTINY.

Containing some letters of Lieutenant Edward Talbot Thackeray, Bengal Engineers, afterwards Colonel Sir E. T. Thackeray, V.C., K.C.B., R.E. (1836–1927), *edited by* BREVET COLONEL C. B. THACKERAY, D.S.O. (*late Lieutenant-Colonel, R.A.*).*

I.—MEERUT.

HAVING passed into the Bengal Engineers through Addiscombe and Chatham, Edward Thackeray arrived at Calcutta in January, 1857, and was posted to the Bengal Sappers and Miners at Roorkee. Fellow passengers on the s.s. *Ripon* were Edward Jones, his greatest friend, first in his term at Addiscombe, and C. Innes, both of the Bengal Engineers, and both killed a few months later.

." At about 8 o'clock on the morning of May 13th, 1857," Thackeray relates, " two or three of the officers were standing outside their quarters looking at a pony which had been brought to the lines for sale, when Lieutenant Ward rode up and called out, ' Have you heard the news? We are to march to Meerut this afternoon.' Shortly afterwards, a parade of the whole Corps was ordered. Nine officers, 50 British non-commissioned officers, and 500 out of 700 native sappers were put under orders to march. By great exertions a sufficient number of boats was collected for the officers and men, and we marched down to the landing-stage and embarked at about 6 p.m. At this time none of us, with the exception of the Commandant, were aware of the state of affairs at Meerut. We thought that a local riot had occurred, and that we were ordered to Meerut for the purpose of helping to quell it, and we expected to be away for about a week. . . .

" On the morning of the second day, we saw a European driving along the left bank of the canal in a buggy. He was, I think, an overseer in the Irrigation Department. We hailed him to ask the state of things at Meerut, but he did not stop. He shouted, ' They're cottin' throrts in Meerut like mad, and burnin' 'ouses,' and drove

* These chapters are an abridgment of the first part of a future publication. Extracts from Sir E. Thackeray's *Two Indian Campaigns* (published in 1896 by the R.E. Institution), and other reminiscences, are distinguished by his initials, thus, [E.T.T.]. His elder and only brother, to whom several of the letters are addressed, was the Rev. F. St. J. Thackeray, Vicar of Mapledurham, and formerly a master at Eton. The brothers were the orphan sons of the Rev. F. Thackeray.—ED.

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on in the direction of Roorkee. On the afternoon of the 14th, we disembarked from the boats, and marched to Meerut, which was about eight miles distant from the canal." [E.T.T.]

THE FIRST LETTER.

E.T.T. to his brother, F.St.J.T.

MEERUT LINES,
May 15th, 1857.

I write you a line to tell you I am safe and well, as I thought you may hear reports, and be alarmed about me. We marched in here this morning at 3 a.m. from Roorkee. We came 40 miles in boats and marched the rest. We slept about three to four hours the whole way. We started on the 13th.

My dear brother, I congratulate you extremely on your success in getting a fellowship. I got your letter the day we left Roorkee. I assure you I was so pleased to hear it, especially just starting on the march.

We knew nothing till we arrived here. . . . We were astounded by the dreadful news we got on arriving. We marched in between European regiments, the Carbineers (Queens) and 60th Rifles. The men were standing at their guns ready. On last Sunday evening, the 10th May, the native regiments, the 3rd Native Lt. Cavalry, the 20th N.I. and 11th N.I., when the Europeans were in Church, set fire to nearly every officer's bungalow in Meerut. The 20th N.I. murdered in cold blood four officers, the 3rd Lt. Cavalry two, and the 11th N.I. two or three. They murdered two officers' wives and children in the most horrible manner. A young officer of the 3rd was hacked to pieces. We got a *fakeer* in yesterday, who murdered one of the ladies, and hanged him in front of the men.

The regiments who got out of here marched straight to Delhi and murdered every European there except a few who escaped. One of our Artillery officers there blew up a thousand of the natives in the magazine, but was killed himself afterwards. We are waiting for more European regiments, and then, I believe, march straight on Delhi. All the officers (not on duty) here stay in one room all day. We are to be out on picket duty from 5 p.m. till 8 a.m. every night. We never stir without revolvers and swords. I hope, dear St. John, you will not be alarmed about me. I am very happy and put my trust in a good Providence. The sappers, I do not think, will ever mutiny.

Thank William Thackeray* for his most useful present to me of a revolver. I am very doubtful if this will reach you, as they are

* His cousin, William Makepeace Thackeray.

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stopping the post. You have no idea how I long, and we all do, to be off to Delhi. It is with difficulty we can restrain the Europeans. We will hang the King of Delhi when we get there. My dear St. John, a mutiny is not a very pleasant thing, but I think in my next letter you shall have better news. The clergyman and his wife at Delhi were murdered in front of the King of Delhi's throne. I am afraid when we arrive they will bolt, but if they do give us a chance we will give it them. You must excuse this very short letter, but I must be off to the Sentries. . . . .

You heard that the reason of the Mutiny was the men having cartridges given them in which was bullock fat, which it is contrary to their religion to put in their mouths.

This does not state the case quite accurately. The suspected cartridges were not issued to the troops. The annexation of Oudh was, politically, the main cause of the Mutiny. The cartridge grievance was more in the nature of a pretext, engineered by the malcontents. But there were many contributory causes.

The immediate cause of the outbreak at Meerut was the public degradation at daybreak on the previous day, Saturday, 9th May, of eighty-five troopers of the 3rd Bengal Cavalry, who had been sentenced to imprisonment for six to ten years by a court martial composed entirely of Indian officers, for mutinously refusing to take the innocuous cartridges issued to them. . . .

On the following day, the Sunday evening service was the appointed hour for the troopers of the 3rd Cavalry to rise. Luckily, they did not know it had been changed, and the troops were not yet *in* church. Their first act was to set free their comrades in the gaol. The 11th and 20th Bengal Infantry rushed to their lines and armed themselves. Bungalows were already being fired in all directions, and their occupants butchered. The scum of the populace joined in the murder and riot. Colonel Finnis, commanding the 11th N.I., had galloped down to his lines, with some of his officers, and was urging his men to remain true to their salt, when he was shot by a soldier of the 20th. Other officers met the same fate. Nearly every stray man, woman and child was murdered, a few being saved by loyal Indian servants.

In the British lines, bugles had sounded and taken up the alarm. Horse, foot and artillery were speedily under arms. But confusion prevailed among those on whose promptness and decision all depended. It was nearly dark before the troops moved off together, the Carabineers (6th Dragoon Guards), 60th Rifles, Tombs's Troop of Bengal Horse Artillery, and Scott's Field Battery. The rebels—actually inferior in strength—had by then disappeared, none knew whither. It was decided to concentrate at the barracks, for the protection of the women and children, under the impression that

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the mutineers were still at large in the city, ready to attack. No steps were taken to follow, or even to keep touch with the rebels, who had fled to Delhi, thirty-six miles distant, where there was no British garrison. The atrocities of Meerut were there repeated. It was sixteen days before a column marched from Meerut. Although the wisdom of this course has been upheld by most of the highest authorities, among them Lord Roberts, the plain soldier cannot help thinking that a little less wisdom and a little more foolhardiness would better have upheld the honour of British arms.

SECOND LETTER.

E.T.T. to his brother, F.St.J.T.

MEERUT LINES.
May 18th, 1857.

The mail does not go till the 20th, and I still have time to give you a line. I hope anything you hear will not alarm you. I am sorry to tell you that the day after I wrote to you, the Sappers and Miners, natives, mutinied. They shot poor Captain Fraser, our Commanding Officer, and fled. The Adjutant* ran the gauntlet of the whole line. The Carabineers and Artillery pursued them and cut down fifty or sixty.

That day I was detailed on duty with ninety of them, destroying walls and bushes which could serve as a cover to an enemy. We were about a mile and a half from the lines. They worked very well and I was talking and laughing with them all day. About 3.30, someone told one of them that the Europeans were killing the Sappers in the Lines. They fled immediately, except about twenty who stayed with me. I had the Serjeant-Major and three other Europeans, non-commissioned officers with me. The natives all had their muskets, and sixty rounds of ammunition. The Serjeant-Major and I rushed after them and endeavoured by persuading and threats to make them fall in. It is a wonder they did not shoot us. At last we got about thirty together, and marched them towards the lines. Before we got there some of the others joined us, and I marched in fifty-four, thirty-six escaping, who were, I believe, afterwards killed. We met a troop of Carabineers. The officer told me the rest of the men had fled, shooting poor Fraser. Poor fellow, we buried him yesterday, and, please God, will soon avenge him. His wife escaped from the massacre at Delhi. The sappers I brought in were immediately disarmed. We have about 120 of them, and they work well. I will never trust natives again. It is a religious panic has seized the whole army.

* Lieutenant, afterwards General Sir F. R. Maunsell, K.C.B., Colonel Commandant R.E.

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I am on picket nearly every night. We have fifty Europeans in the Sappers, which is a great thing. We are about 2,000 Europeans strong here. How we wish they would attack us. A native was shot by his own men protecting Fraser. I never knew what a wound a bullet could make before I saw him. His head was blown to pieces. Men are hung in camp every day. We are expecting Jones and Carnegie every hour. They were at Missourie and have to join alone. I trust we shall march on Delhi soon. You have no idea how sharp you get at answering the sentries. If you don't say "Friend" instantly, they fire.

I am very well, thank God, and all our officers. . . . We are all in very good spirits. . . . I don't think that there ever was a body of men who would fight better than our garrison. We have lots of Artillery. The Carabineers are splendid fellows. . . .

I hope you will be able to read this. . . . It is rather a sharp opening of a soldier's life. We are fortifying the place every day. I am afraid I shall lose all my books and saddles. I started from Roorkee prepared for a week's campaign.

The mutiny of the Sappers is thus described elsewhere by Sir E. Thackeray:

"Early on the morning of the 16th May, I received orders from Captain Fraser, the Commandant, to take a party, consisting of 3 British non-commissioned officers and 90 native sappers, to the Grand Trunk Road, leading from the northern part of the city to Delhi, for the purpose of dismantling some old walls which had been built near the sides of the road. It was anticipated that an attack might be made by the rebels from Delhi. . . . I never saw Fraser again alive. The sun beat down fiercely on our little party, and the hot wind felt like the air from a furnace as we passed the deserted and blackened remains of the bungalows, which the Sepoys had set on fire a few days before. As we passed through the streets of the bazaar, the natives peered over the walls at us, and I remarked to the serjeant on their furtive and scowling looks.

". . . A large portion of the walls had been demolished, when a little after 3 o'clock my attention became attracted by the sound of bugles in the direction of the cantonment. Almost at the same time, a native trooper of the 3rd Light Cavalry galloped down the road at the side of which the sappers were working. He was in uniform, fully-armed, with sword at his side and pistols in his holsters. His horse's mouth and flanks were lathered with foam, and he gesticulated and pointed in the direction of Delhi. I turned to look towards the men, and saw that many of them had laid down their pickaxes and shovels, and had run to the piles of muskets, from which they commenced taking their arms. Before any order could

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be given, they were running along the road, following the trooper in the direction of Delhi. I then ordered the bugler to sound the assembly, and by dint of threats and expostulation, and with the aid of the European serjeants, we succeeded in inducing 36 men to fall in. Looking towards the houses in the vicinity, I could now see large numbers of the Meerut *budmashes* (ruffians) collecting near the bazaar, and poking their heads over the walls, as if expecting to see what was coming next. I ordered the little detachment to march to the lines, and before proceeding far we were joined by 28 men, who had at the first bugle call been undecided, but finally made up their minds to rejoin their comrades who had remained staunch.

". . . I saw the body of the havildar who had tried to save the Commandant. He was lying on his face on the ground, the back part of his head having been blown away by a shot from behind.... The sight of the corpse of this faithful soldier, treacherously slain by a Sepoy while trying to save the life of his commanding officer, roused in the minds of all who saw it feelings of anger, and a desire for stern retribution against the mutineers. I now learnt that, while Captain Fraser was issuing orders for the removal of the ammunition to the magazine, he was shot from behind by one of the Sepoys, and the havildar was killed at the same time while trying to protect him. The Sepoys then fired at the Adjutant (Lieutenant Maunsell), who had a most narrow escape. After the murder of the Commandant and the havildar, the Sappers fled from the cantonment. They were pursued by the Carabineers, and a party, consisting of about 50 men, were overtaken among the sand hills. They took up a position under cover of the hillocks, and commenced firing at the Carabineers. They were, however, overpowered and killed.

" Lieutenant David Ward, of the Engineers, had on the morning of the same day also been sent out with a party of sappers by Captain Fraser, to execute some entrenching work on one side of the station. This party remained faithful, and Lieutenant Ward brought them back to the lines, where they were disarmed. On the following morning, some of these men expressed a wish to be allowed to go out to bury their comrades who had been killed by the Carabineers. Lieutenant Ward volunteered to accompany them, and went out with a party of Sappers to bury the men who had been killed on the previous day. This was a highly dangerous service, as it was thought at the time that the sight of their slain comrades might excite the passions of the men. Ward brought back his party to the lines after this hazardous duty." [E.T.T.]

It is a curious commentary on the attitude of those in command, that bodies of armed sepoys, known to be disaffected, should have been sent out under inexperienced young British officers, as though conditions were quite normal. In justice to

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the loyal few, Sir Henry Norman's official account of the Siege of Delhi, published in 1858, may here be quoted: "The remnant of the old corps of Sappers and Miners behaved with the most perfect fidelity, and on numerous occasions with exemplary gallantry, notwithstanding that the bulk of their comrades were opposed to them." They were the only trained sappers present at the Siege, and the value of their services to the army cannot be exaggerated. For this result, great credit is due to the two young officers, Thackeray and Ward, who brought their men back with them to the lines. At the end of the Siege, the sappers were the only Hindustanis from Lower India still serving with the army.

"We had now about 50 European non-commissioned officers, and about 150 native sappers. The latter did excellent work in fortifying the Dum-Dumma and other buildings in the station. . . . Two days after the Mutiny of the Sappers, I received orders to take a small detachment of the 3rd Light Cavalry to a village, distant about seven miles from Meerut, to collect some tools. The *sowars*, or troopers, were the remnant of the regiment who had mutinied on the 11th, and gone off to Delhi, after killing two of their officers.

"On the afternoon of the 27th May, to our great delight, the long-expected order was issued for a column, under the command of Brigadier Archdale Wilson, to march towards Delhi, to join the force which was moving down from Umballa, under the Commander-in-Chief, for the capture of the city of Delhi. . . ." [E.T.T.]

Third Letter.

E.T.T. to his brother, F.St.J.T.

Camp Ghazeeoodeennugger
(10 miles from Delhi).
June 1st, 1857.

I hope you won't be alarmed by the length of the name of the place where our Camp is pitched at present. I don't know whether you received two letters I wrote from Meerut, but since I wrote them I have really not had time to write a line. Events have happened so quickly and we have had so much to do. However, I will try to give you an account of it all as well as I can.

When I first arrived in India, the first sign of disaffection among the Sepoys took place at Barrackpore, close to Calcutta, the Sepoys refusing to use their cartridges on account of bullocks' fat being in them. You know it is contrary to their religion to touch either bullocks' or pigs' flesh, and about this they are very particular.

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The cartridges were then changed, but ever since the troops were in a bad state. At last the 19th and 34th Regts. N.I. were disbanded and several of the Sepoys hung.

The next place where the troops became disaffected was Umballa and then Meerut. It was at Meerut, a day before the great outbreak, that 85 Sepoys were imprisoned with hard labour for 14 years, which is supposed to be the cause. (*See page* 453.) Many people think that the religion is only an excuse and that the King of Oudh and other Rajahs are at the bottom of it. However, I don't pretend to know the cause, but one thing is certain that there is, as some distinguished person says, 'a row in the house.' I am sorry to say that now about 20 regiments have mutinied. At Roorkee, we had no idea of anything, when, on May 13th, an order came for us to march to Meerut. I gave you an account of our march there and the mutiny of the Sappers, when they shot poor Fraser, our Commandant.

There is a place at Meerut called Sudder Bazaar, and when the regiments mutinied the people came out of this and murdered the English in the most horrible manner. Two English ladies, officers' wives, were cut to pieces and burned to death. Many children were murdered. I cannot tell you the details of some of the murders, they are too horrible. Four Sapper serjeants who were not attached to the regiment and were living in a bungalow, were brutally murdered with their wives. How I long to go in at them at Delhi. You will be surprised to hear I have seen a good deal of fighting and been under a very heavy fire already. However, of that presently. I tell you of those murders, because I know you would like a true account. When the regiments at Meerut mutinied (all Sepoys, of course), they marched to Delhi (why they were not cut up by the Carabineers, I don't know). At Delhi, there is an immense magazine and it has often been wondered why it was left entirely in charge of native troops, the 54th, 47th and 38th Regts. N.I. and some Artillery being the only force there.

When the mutineers arrived at Delhi the regiments there were on parade. The mutineers of the 3rd Light Cavalry rushed on to the parade of the 54th and pistolled the European officers in front of their men, who never attempted to protect them. This was the signal for a general massacre. The other regiments shot their European officers, and every European in Delhi, except about 40 who escaped, was murdered. The King of Delhi at the head of it all. Poor Mrs. Fraser was at Delhi, but escaped. Her child was murdered. A party of 12 gentlemen and several ladies escaped. They walked the whole way from Delhi to Meerut (40 miles). They were pelted with stones at many villages they passed through. They were robbed of everything they had, and were nearly naked. They

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lived on grain or anything they could get. Lieut. Salkeld, Engineers,* was of this party. He is now with our force.

. . . The Sappers mutinied about the 16th. About 100 of them stayed. We have 50 European N.C. officers, which is a great thing. Other regiments which mutinied had no Europeans except the officers. . . . (*Continued.*)

THE ACTION ON THE HINDUN. [E.T.T.].

"The column which marched out of Meerut under Brigadier Archdale Wilson, on the 27th May, consisted of two squadrons of the Carabineers, a wing of the 60th Rifles, Scott's Light Field Battery, Tombs' Troop of Horse Artillery, two 18-pounders, all manned by Europeans, with a small detachment of native sappers and some irregular horse. On the 30th May, the column arrived on the left bank of the River Hindun, near a place called Ghazee-oo-deen-nugger. I visited the place in 1868, eleven years after the battle. . . . The ditch round the village, which I recollect to have seen filled with dead mutineers, had been filled up and the walls levelled. . . .

"At the camp on the Hindun, 14 Engineer officers occupied one European private's tent, with a single thickness of canvas. . . . The heat was so intense that we wrapped wet towels round our heads, and lay down with our heads under the solitary table that we had brought as a mess table. About three o'clock in the afternoon a round shot was fired into the camp from the opposite side of the river. The shot killed a non-commissioned officer of the Carabineers. The bugles sounded, and the troops fell in, and at once marched towards the bridge that spanned the river. The shot fell thickly about as we advanced. The mutineers, flushed with success, had come out from Delhi to give battle to the Meerut Brigade before its junction with the Umballa force. . . . Under cover of the guns, the 60th Rifles advanced to close quarters with the enemy. The mutineers broke and fled under the galling fire poured in upon them, and numbers were bayoneted. They left five guns in our hands. Major Tombs, with the Horse Artillery and Carabineers, dashed across the Hindun to the right, and successfully turned the left flank of the enemy. Major Tombs' horse was shot under him during the action. A Sepoy of the 11th Regiment fired his musket into an ammunition wagon just as a party of the 60th, under Captain Andrewes, were gallantly seizing the guns. Captain Andrewes and several men of the 60th were killed by the explosion and others were carried away wounded.

"About noon on the following day, Whit Sunday, the bugles again sounded the alarm. The enemy had again come out from Delhi,

* Lieut. Philip Salkeld, V.C., who died on 11th October of wounds received at the blowing in of the Kashmir Gate. Lieut. Willoughby, who had blown up the magazine, was also of the party, but was murdered on the way.

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and had taken up a position on the right bank of the Hindun, about a mile from our advanced posts on the bridge. . . . The fight was one almost entirely of artillery. When the enemy's fire slackened, a general advance was ordered, and the enemy retreated, carrying off their guns to Delhi. Our men were so exhausted by the heat, and by thirst, that they were unable to improve their victory." Seven hundred British soldiers had, however, signally defeated seven times their number.

THIRD LETTER (CONTINUED).

E.T.T. to his brother, F.St.J.T.

June 1st, 1857.

(*Page missing.*)

. . . . I cannot tell you our correct loss, but I do not think it was more than 30 killed and wounded. . . . .

Yesterday, Sunday, about 9 o'clock a.m., the force turned out again, but the enemy did not advance till about 12. When I say advance, I mean they came so near as to be carefully out of range. We were employed making a sand-bag battery to defend the ditch. After the Artillery and Rifles had advanced, half the Sappers were ordered to advance and support one of the guns. (I forgot to tell you that first a round shot came right into our battery. We saw it coming bobbing quickly along the road. We got out of the way as we could, but one of our serjeants was rather too late. It just grazed the calf of his leg, but has not wounded him severely, though it is much swollen. It was a wonderful escape.) I went with the half of the Sappers to the Fort, the other officers were McNeill and Carnegie and Geneste. We ran two miles in the heat of the day. The grape were tearing the trees all round us. Such a whistle they make, knocking up the dust all round us. We were a very small body to which I suppose we owe our escape. I thank God for his mercy in having spared us. We got up to the heights and drove the enemy back. We took no guns yesterday as they kept them in the rear. We spread out in skirmishing order and popped away at them. Our Quartermaster-Serjeant had a rifle. I saw him shoot one of them at about nine hundred yards. We could not get near enough for me to use my revolver.

Poor Lieut. Perkins, Artillery, a very fine fellow, was killed by a grape shot. Twelve of the Rifles were struck down by the sun, four of them died. The heat was fearful. When the water-carriers came up the rush was tremendous. I suffered very much from thirst. I always wear white clothes, and a hat made of pith, a sort of helmet, as a protection. I think it was owing to their small cloth caps the Rifles suffered so. I saw one man sun-struck, he was raving. Our

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loss was very small. I saw a good many of the enemy dead. Round shot had hit some of them and knocked them to pieces. We drove them back. I wish we could advance, as it is very harassing work out in the sun all day. I was out about 12 hours yesterday. Hurrah, the Gurkha Rifles have just marched into camp. They are a hill regiment and hate the Sepoys. They are 600 strong and splendid little fellows, very like Europeans. They marched 70 miles in two days. We probably shall be turned out again this afternoon. . . . I hope you will be able to read this, but as the penitent convict at Newgate says at the end of a long letter in verse (*vide Punch*) :

" I writes this from my little Cot,
Best of times is bed."

The table in the tent being occupied by sleeping officers and the thermometer about 100 in the tent. However, I think the convict was better off than us, our little cots consisting of a rug and a pillow on the ground, and I don't think I ever slept so soundly in my life as I do at night here.

This is the first quiet morning I have had. I daresay I have written a great deal about what is not very much to what we shall have, but I thought you would like to hear all about it and being the first time I was under fire. Jones is here. I never was better in my life than I am now, and we are all very jolly and have great fun. We have hardly any knives or anything. Your present to me of a cup, knife, etc., is invaluable.

I am so glad you have a fellowship. . . . I must now conclude, for I am thoroughly tired. . . . .

P.S.—Am very lucky in getting into action so soon.

THE BATTLE OF BADLE-KA-SERAI (*Alipore*). [E.T.T.]

" We remained in our position on the Hindun from the 1st to the 5th June, and on the evening of the 5th, we commenced our march to join the force that was moving down from Umballa, under the Commander-in-Chief, General the Honourable G. Anson. . . .

" On the morning of the 7th, we joined forces with the Umballa column. The meeting with old friends caused much rejoicing, and all were eager for the attack on the enemy's position at Badle-ka-Serai, which it was known would be made on the following morning. . . . We now learnt that Major-General Sir Henry Barnard had succeeded to the command, on the death from cholera of the Commander-in-Chief, General Anson. On the 6th, the siege train of 28 pieces arrived. On the morning of the 8th, we marched out of Alipore at 3 a.m., to attack the enemy, who were strongly entrenched at Badle-ka-Serai, their forces consisting of cavalry and infantry and 30 guns."

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FOURTH LETTER.

E.T.T. to his Aunt, Miss Henrietta Shakespear.

CAMP DELHI
(Heights above).
June 20th, '57.

. . . I am, thank God, quite well, and never was better, though we are out in the sun or at night 8 hours out of the 24. I received two very nice letters from you, here in camp. You can't think how glad I was to get them, because I am afraid the post is not very safe in these stirring times here. However, I hope we shall soon be in Delhi, and then I will write lots of letters.

We marched down the River Hindun and joined the Umballa force on the 7th of June (after two nights' hard marches), about eight miles from Delhi. The next morning we advanced on Delhi. The Umballa force consisted of H.M. 9th Lancers, H.M. 75th Regt., the 1st and 2nd Bengal Fusiliers (Europeans), and Artillery. The force which came from Meerut, as I told St. John, consisted of H.M. 6th Carabineers, H.M. 60th Rifles, Artillery and Sappers.

July 2nd. We have had so much to do in the last week, I have not had time to write till to-day. We are eight hours out of the twenty-four in the batteries, and we get so tired we can't write much.

I will go on from where I left off, the event of the 8th of June. We started about 3 o'clock in the morning, in order of battle. I was with a company of Sappers (you know they did not all go at the Mutiny—about 200 stayed); I in the 3rd column. After we had marched about two or three miles, the sound of heavy guns was heard in front, and we knew the 1st column was engaged. I never knew anything more exciting than getting closer and closer, and then the round shot and shell began to whistle past us, and tear up the ground all around. The Ghurka Regiment and 75th Queen's were with us. Men were carried past us in palanqueens—poor fellows, many dead and badly wounded. We passed one of our light batteries which had met the brunt of the enemy fire. One tumbril had blown up, and two or three Artillery men lying dreadfully scorched and dying in the road. I never saw such a ruin. Dead bullocks were lying all about. The enemy had taken up a splendid position and made a very strong battery about four miles from here. We drove them out of this. In fact they never waited to let us come up, but ran for it. We captured four heavy guns here. Many of the enemy got inside a strong-walled sort of village, which was barricaded, where they fired at our men. Our little party of Sappers came up and we burst open the doors and rushed in. We

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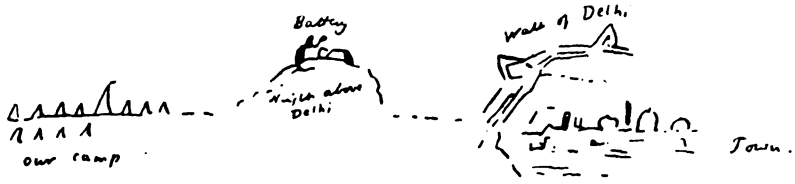
had orders to destroy all the villages on the way which had harboured the rebels. No quarter is given to them. I daresay you will think this cruel, but if you think of the horrible massacres of our women and children and of the mutinies where six or seven European officers were shot down in front of their native regiments, without a man trying to help them, you will see it could not be otherwise. After taking this position, our force rested about half an hour and then we again advanced. The enemy retired to the heights above Delhi, where we are now. They poured a very heavy fire on us as we



advanced, but they never waited to let us come close, but fled into Delhi, leaving altogether 20 guns in our possession. Col. Chester (Adjutant General) was killed, Capt. Russell, Lieut. Harrison, and about 50 men on our side, and about 150 wounded. The enemy lost great numbers. I saw many of them on the road. It was a glorious day, but I wish we had followed it up, as we have since remained here, and lost many men in skirmishes with the enemy. . . . (*Continued.*)

The battle of Badle-ka-Serai was one of the most decisive of th Mutiny, for it gave us the Ridge, from which we were able to prosecute the "siege" of Delhi. Of the enemy opposed to us, it was reckoned that 1,000 never returned to Delhi; 13 guns were captured.

"The troops were posted at intervals along the ridge which overlooks the city. We were all much exhausted after the action and the march under a hot sun. . . . The Camp was pitched in rear of the ridge, and a bungalow that had partially escaped the conflagration after the Delhi massacre was told off for the headquarters of the Engineers. We located our mess in the billiard-room." [E.T.T.]

(*To be continued.*)

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ROORKEE PATTERN STEEL CRIBS.

By BT. LIEUT.-COLONEL G. LE Q. MARTEL, D.S.O., M.C., R.E.

VARIOUS types of trestle equipment have been tried at different times and used with varying success. For the lighter loads the normal type of trestle, with two legs and a transom adjustable for height, has proved satisfactory over a large number of years, but the design of a heavy trestle or trestle tower for the heavier loads produces many complications. The transom has in this case to be of considerable weight, and there is difficulty in distributing the heavy loads in each leg on to the ground. Moreover, a large and awkward trestle has to be erected, even if a low trestle about 4 ft. high is all that is required, and short trestles are very commonly needed. Again, if a high trestle, say 20 ft. in height, is required for a deep, dry gap in rugged mountainous country or for railway work, the normal trestle equipment is useless. The necessity for being able to adjust the height of the transom without disturbing the roadway, only arises in the case of tidal ramps and, as not one per cent. of the trestles erected in war are required for this purpose, the point is not one of importance. It is true that an adjustable transom enables the transom to be raised if the legs sink or settle unevenly, and with very light trestles this is a distinct advantage, but with the heavy modern loads, such as tanks or the heavy armoured cars, a trestle bridge resting on insecure foundations in this way would be quite unsafe and impracticable. In addition to the normal type of trestle equipment, tubular trestle work has been tried and used, but although this type of work is very suitable for scaffolding and many other purposes, it does not appear at its best for trestle work, and the tubes have to be cut to length or packing used to obtain the right height for the heavier loads. Another method of solving the problem of rapid trestle work is the existing steel cube, but this is heavy and slow for anything except the very heaviest loads.

As an alternative to the above some steel cribs have been constructed at Roorkee, as shown in Fig. 1 in the drawing. There are only two types of crib ; they take the form of a skeleton steel box, 18 in. square, and are made in 3 ft. and 6 ft. lengths. The cribs can be joined together in any direction by using four $\frac{3}{4}$-in. bolts. Thus, piers or trestles can be built to any height by 18-in. stages. The strength of any crib is 12 tons in compression in any direction.

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The drawing shows various types of trestle and pier, but these can be varied to an endless extent. Details of the cribs are as follows:—

	3-*ft. crib.*	6-*ft. crib.*
Weight	105 lb.	195 lb.
Safe thrust	12 tons	12 tons
Limiting shear stress against bending ...	1½ tons	1½ tons
Limiting bending moment in one box ...	180 inch tons	180 inch tons
Cost of material in India for one box ...	11 Rs.	20 Rs.

Note.—One 6-ft. box supported at the ends will carry a concentrated or distributed load of 3 tons against bending, the limit being failure by shear, but these cribs are not really intended to take bending moments.

The sides of these cribs and the vertical members are all made from 2 in. x 2 in. x $\frac{3}{16}$ in. angle, and the diagonal bracing on the sides and ends is made from 1¼ in. x $\frac{3}{16}$ in. flat, mild steel.

Fig. 2 in the drawing shows a typical medium trestle built from these cribs. This was used in a test to support one end of a girder bridge across a 60-ft. span. The bridge itself weighed 14 tons and lorries weighing about 5 tons were passed over repeatedly; the trestle appeared to take the weight quite easily and was particularly free from any sign of vibration or sway under the load.

This medium trestle consists of four 6-ft. cribs and one 3-ft. crib, and short 4 in. x 2 in. channels are used to distribute the weight of a timber transom on to the trestle. The total weight of the trestle, including the timber transom and short channels, comes to 1,237 lb., which is just a little less than the medium trestle of the pontoon bridging equipment, and it is, of course, far more rigid than the trestle equipment would be when used at this height from the ground. This test was really on overload, as a heavy trestle would normally be used with such heavy girder work.

Figs. 3 and 4 show two typical types of heavy trestle, using four uprights instead of the two in the medium trestle. Any of these trestles can, of course, be varied in height by 18-in. stages quite easily. The heavy trestle should carry loads up to 20 or 30 tons for heights up to, say, 14 ft. For greater heights, it should prove better to use two trestles built together as a tower. Fig. 5 shows the side view of a typical tower of this type. The type shown is 18 ft. high and consists of two heavy trestles. These trestles are bound together at the top and the bottom by 3-ft. cribs, and in the centre they are bonded together by using 6-ft. cribs, which are placed under the uprights in the top half of the trestles.

In the tests that have so far been carried out, these cribs appear to make such a rigid trestle that no lateral bracing or struts appear to be necessary. Longitudinal bracing will, however, often be required, especially when trestles are used by themselves, and not built up into trestle towers. For this purpose it is proposed to bolt angles of 18 in. x 3 in. x 3 in. x ⅜ in. mild steel on to the sides of the

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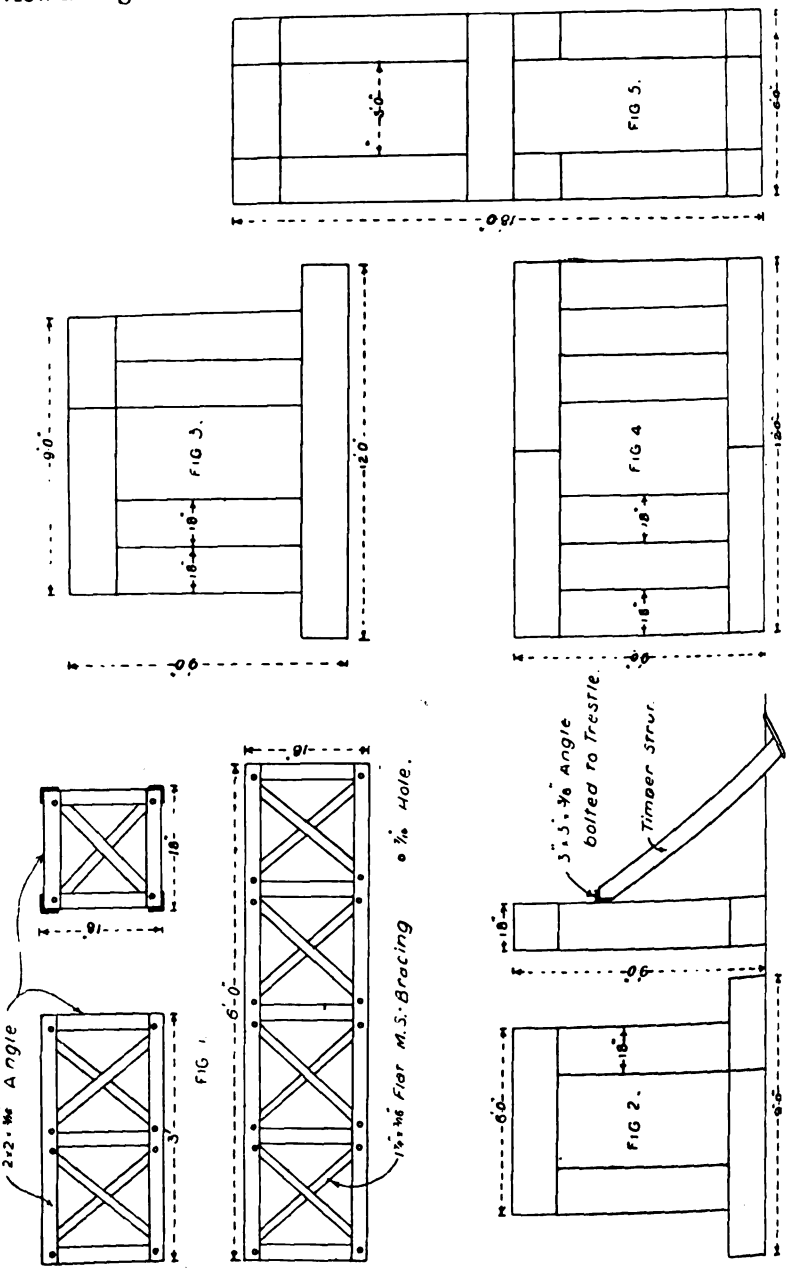
trestles and fit timber struts into these angles as shown in the side view in Fig. 2.



In addition to the above, it is proposed to try some of these boxes joined end to end as a long column for use as a derrick. For this

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purpose, special end pieces are needed which taper to a point, and it is proposed to use fish-plates in addition to the ordinary $\frac{3}{8}$-in. bolts for joining them together, so as to increase the strength of the column in resisting a bending moment. These fish-plates should not be used for trestle work, as they are unnecessary for this purpose.

The design of these cribs has been worked out in detail at Roorkee, and the necessary jigs made so that they can be manufactured without skilled labour and to ensure that they shall all be interchangeable. The trials that have been carried out up to date show that these cribs can be built up very rapidly and that they are very light and cheap; a small fixed spanner is provided for tightening the nuts. It is true that the present medium trestle equipment could be lightened if it was re-designed, but it would still be heavier for short trestles and incapable of use for trestle work over 14 ft. high. Moreover, this method of using crib work provides a groundsill with a good distribution of weight, which is a very weak point in the present trestle equipment for medium or heavy loads. It therefore looks as though it may become possible to use some form of steel crib work of this nature to fulfil all military requirements for medium and heavy piers, and if this proves to be the case we may then be able to revert to a really light and handy trestle as our trestle equipment for the lighter loads. These cribs are also very useful for the rapid erection of towers for water tanks, searchlights, etc.

The design will no doubt be improved on in detail; for instance, the flat bracing may be found to be liable to damage if the cribs are thrown about. Angles of $1\frac{1}{4}$ in. x $1\frac{1}{4}$ in. x $\frac{3}{16}$ in. might be used, in which case one diagonal might suffice as it could take compression, but the flat bracing has the advantage that it is easier to tighten the nuts up inside the cribs. They will stand a fair amount of rough handling and as the 6-ft. boxes weigh less than 200 lb. there is no excuse for unduly rough treatment. The cribs in their present form are cheap and we can afford to throw away damaged ones, and this may be better than trying to make them proof against all rough handling. It is possible also that welding may be found suitable as a means of construction and this would probably provide a stronger crib for the same weight.

There will, of course, be a temptation to complicate the idea and provide such things as swivelling attachments to enable the outside legs to be splayed. It is suggested, however, that we should not add too many complications and frills. In the present design, everything is extremely simple and easy and appears to work well, and although it may possibly be found advantageous to add a few more shapes and sizes of cribs, the temptation to complicate the scheme and lose the present simplicity should be guarded against.

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BRIDGING ON THE NORTH-WEST FRONTIER OF INDIA.

By COLONEL C. H. HASWELL, C.I.E., *Deputy Chief Engineer and Secretary, Public Works Department, North-West Frontier Province.*

WITH the advent of mechanical transport and motor-cars, the question of road bridges on the roads of the North-West Frontier of India has become a matter of great importance. Prior to 1917 only one large bridge existed, the Connaught Bridge across the Swat River at Chakdarra, on the road to Chitral, constructed by Captain Biddulph, R.E., in 1902. This is a steel girder bridge consisting of five spans of 160 feet each. A few masonry bridges existed on the road between Kohat and Bannu, and on these bridges forty-foot brick arches were used.

There are a very large number of dry torrent beds traversed by the main arteries of communication, and in the days of tongas this did not affect traffic. All torrents are subject to heavy floods after rain, lasting from four to twenty-four hours, and if one arrived at a river in flood, it was a case of waiting till the flood had subsided sufficiently to allow the tonga to get across. After a flood, the bed of the nullah was cleared and smoothed, and left till the next flood washed it away.

Between 1907 and 1917, masonry causeways were constructed in many of these dry river beds, but a great deal of money has been wasted in maintenance and repairs, and for mechanical transport a causeway is never satisfactory in any river bed where the slope and velocity of water are great. It is a sad fact that not one single main road in the North-West Frontier Province can be guaranteed open for through traffic during or after rain. Great strides have been made in the last few years, but a great deal still remains to be done.

In 1916, the first of the new set of bridges was taken in hand, and it so happened that, at this time, the North-Western Railway were replacing their girder bridges with heavier types to cope with the increased load of locomotives and rolling-stock. A large number of old girders, quite suitable for road bridges but useless for railway work, were therefore available, and the first bridge across the Raisan River, on the road between Kohat and Parachinar, was constructed of pin Warren girders, picked off the scrap heaps of the North-Western Railway, which were erected at a cost of approximately Rs. 150 per ton.

The Military Engineer Services put in the foundations and piers, the Railway Bridge Engineer fabricated and erected the girders with his trained bridge gangs, and the flooring, consisting of either steel troughing or a reinforced concrete slab, was finished off by the Military Engineer Services.

Thus bridges could be constructed at a minimum cost.

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All girder bridges are now provided by the Bridge Engineer of the North-Western Railway from old material, with a consequent great saving in capital cost.

The point that rules bridging is finance, and for years endeavours have been made to find a type of bridging which is cheap and yet satisfactory. The difficulty which engineers are up against in boulder torrents is the moving bed. In most rivers there is an underground flow, and, during floods, the top portion of the bed from a depth of four to fourteen feet, according to the volume of the flood, is in suspension and rolls. This brings very severe pressure against the piers, and unless they are founded well down into the solid bed and well below the limit of scour, they are apt to tip over, as has happened in many cases.

When constructing the piers for the bridge across the Kurram River at Thal, a great volume of water was met, and eight-inch centrifugal pumps were used to deal with it.

Owing to the water, the sides of the excavation needed shoring, and it was found possible to drive 80-lb. rails to a depth of thirty feet with an ordinary monkey.

The rails were braced, shoring timbers hooked on to the rails, and the amount of excavation reduced and simplified.

After a series of floods, the rail piles were found still standing intact and this led to the belief that piles were a possible solution for road bridges in the North-West Frontier Province.

In 1923, steel screw piles,* constructed by Messrs. Braithwaite & Co., came to the notice of military engineers, and these have been tried with great success in boulder beds. The screw is cast steel, three-and-a-half feet diameter, with a pitch of six inches. The shank is seven inches diameter forged steel. With the aid of a water jet, these screws can be put down to a depth of twenty-five feet, but if a boulder larger than six inches is met, which cannot be moved by the screw, the boulder has to be dug out.

The screws are taken down to bed level and a steel trestle to carry the roadway is bolted on. An elaborate and expensive electric capstan is required to drive the screw, and as the material of the bridge is all steel, the carriage item is expensive. This form of bridge costs approximately Rs. 450 per foot run for a twelve-foot width of roadway. In an endeavour to reduce costs, reinforced concrete pre-cast piles were tried, but these splintered before they had been driven six feet into a nullah bed.

In 1927, a pamphlet describing the vibro-concrete piling system came to notice, and as it seemed too easy, it took some time to get the idea accepted. Eventually, the Government of India agreed to the provision of one seventeen-inch piling plant and an experiment was tried on the Khiali nullah, one of the branches of the Swat River, on the road between Peshawar and Charsadda.

* See "Rapid Bridge Construction in South India," *R.E. Journal*, March, 1928.

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This nullah was chosen for two reasons :—

(*a*) It was a hard boulder bed, and if piles could be driven into this sort of nullah bed, they could be put in anywhere.

(*b*) There is sufficient water during the cold weather to enable a boat bridge to be maintained. In the flood season, logs float down and cause severe damage to the boats, and the boat bridge is sometimes closed for days, for repairs.

A permanent bridge was decided on and has been constructed during 1928. The work has been under the supervision of Captain M. R. Jefferis, M.C., R.E., and it is due to his ingenuity and perseverance that it has been a very great success, and has, it is believed, solved the question of cheap bridging in the North-West Frontier Province. (*Photo* 1.)

The principle is a very simple one. A hollow steel tube, closed at the end with a removable shoe, is driven to the required depth by the latest form of pile-driving machinery. Being steel, the tube will go through anything except rock, as it will stand a twenty-ton blow.

When driven, the reinforcement cage is let down, and the tube filled with concrete. Withdrawing links are then fitted on to lugs on the tube and the action of the hammer reversed. The tube is then gradually withdrawn, being driven back a small amount at each blow. This shakes and, at the same time, rams the concrete into the space where the tube was. Thus a green concrete reinforced pile is formed without any chance of splintering or damage.

In some cases when driving in a boulder bed, the tube is apt to get off the straight. Any eccentricity is corrected by connecting the piles of one bent by a ground sill, moulded at bed level.

On this sill the concrete trestle is moulded, which carries the roadway of the bridge. (*Photo* 2.)

In river beds which can be dried by moving the water about, the system is ideal, but in water the present methods are not quite satisfactory. The difficulties will be overcome by driving a cast-iron pipe on the outside of the steel tube, down into the solid bed, and leaving the C.I. pipe permanently. The outside pipe will give greater strength to the pile at the point between the moving and the solid bed, and will also protect the surface of the concrete against erosion by water and gravel.

The following rough costs show the cheapness of this form of bridge against other types :—

	Per foot run approximately. Rs.
Masonry piers with steel girders	1,200
Steel screw piles with steel trestles and decking	450
Vibro-concrete pile piers with R.S.J.s and concrete decking	150

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One great item of saving is in carriage of materials. In all river beds, sand and gravel suitable for good concrete can be obtained, and therefore only cement, the R.S.J.s for the road bearers, and the reinforcement have to be taken to site.

As most bridges which have to be constructed are miles away from any railway, this is a very important consideration.

It is now proved satisfactorily that the system is sound, and it is intended to gradually replace causeways, as they are washed away, with this form of bridging. The mechanical side of the plant was at first a difficulty, but the Pathan is adaptable, and Captain Jefferis has been able to train almost expert gangs from local material.

The following is a detailed report of the methods adopted by Captain Jefferis for the construction of the Khiali Bridge, with calculations and comparative costs :—

Nature of rivers—The Kabul and the Swat rivers enter the Peshawar plain through gorges in the hills. From these points they spread out, the former into four main branches, the latter into two. All these branches are of similar nature. Their average bed slopes vary from 1/600 to 1/1,200. The widths vary from 500 feet to 1,200 feet. In the main, the banks are from one to six feet above high flood level.

The bed consists of boulders in gravel with pockets of sand; the boulders are approximately ninety-eight per cent. six inches to twelve inches, with two per cent. larger boulders up to a maximum of two feet diameter. The lower portion of the banks is of a similar consistency, the upper portion being mainly silt and sand hardening into "pat."

The permanent or winter water only fills about half the nullah bed and then only in a series of shoals and pools. A maximum of five feet may be taken for the depth of water during the winter. Many fords across the river do not exceed eighteen inches in depth.

These conditions prevail from the beginning of October to the end of March, when the snow water begins to melt. For the remaining six months, the surface level of the water is four feet to five feet higher and the velocity of the river attains about ten m.p.h. After heavy rains in the hills a further rise of as much as five to six feet is sometimes experienced.

These rivers bring down deodar logs from Swat, Kohistan and Afghanistan during the flood season from May to September, and when the floods subside many logs are left high and dry all along the river banks. These logs come down on the first flood of the next season and do considerable damage to boat bridges, as they are not controlled. The biggest logs weigh about five tons and measure some four feet in diameter and twenty feet in length.

Stability of rivers.—The relative quantity of water passing down the various branches of the rivers varies from year to year, depending on the position of banks and shoals at the point where the branches

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separate. A branch in high flood carrying an unduly large proportion of water may overtop its banks in some places. This may lead to a new channel being cut out. This channel, however, is unlikely to be cut out deeper than the main stream in one flood, and it is considered very unlikely that in such a case the river could not be returned to its original bed by suitable training works.

Erosion of the banks is of seasonal occurrence. It has been found, however, that boulder stone bunds in wire crates can withstand the set of the river if properly maintained every year. A set of the river at any one point does not normally continue for more than three or four years at a time.

The principle on which the bridges have been sited has been to give the river adequate waterway and in no way to attempt to force it through an abnormally narrow channel. In fact, sites have been chosen greater than the minimum obtainable, in order to allow for the decrease in the waterway due to the pile bents.

Type of bridge.—The Michni Bridge, constructed in 1914, is situated where the main Kabul River enters the plain. It consists of 100-foot steel girder spans on masonry piers. The latter were sunk on a curb, pumps and grabs being used to excavate inside them.

The greatest difficulty was experienced in sinking these wells, due to the large boulders in the bed of the river, and it was not found possible to go more than twelve feet below mean nullah bed level or eight feet, say, below maximum nullah bed level. This leaves a very small margin for scour and is the cause of grave anxiety now, as one pier has settled slightly. Sheet piling, unless of exceptionally heavy section, could not penetrate the nullah bed.

It was therefore considered that some form of pile bridge would prove the most economical form of construction.

Vibro-concrete piling plant.—The only pile which could be sunk in a nullah bed of the nature existing would be a steel pile. As the cost of construction with permanent steel piles would be prohibitive, the vibro piling plant or some similar form of plant only remained.

The plant consists of a boiler, winch and 45-foot jib carrying the tube and hammer, the whole mounted on a base fitted with rollers. The winch is capable of a pull of three tons on each of two drums. It is also fitted with two external capstans. (*Photo* 3.)

The jib is constructed of timber, with steel leaders for the hammer and pile. It is also hinged at the bottom front edge, so that it can be assembled on the ground and hoisted later. The 2-ton hammer is of the ordinary single-acting, semi-automatic type except that it has a special automatic fitting for reversing the action of the hammer and withdrawing the pile.

The pile is a 16-inch drawn-steel tube $\frac{3}{4}$-inch thick, with a cast-iron head, which has a filling hole projecting to the front and a bulge at the bottom increasing the diameter to seventeen inches. A detachable cast-iron shoe is fitted loosely in the bottom and a

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cast-iron cap on the head carrying a wooden dolly. The links are carried by wire rope tackle, capable of fifteen-ton pull, and hook on to lugs on each side of the pile head, or the cap on the hammer. A wire rope from the second winch drum carries the concrete skip.

The method of driving is as follows :—The shoe is placed under the pile tube, the hammer lowered on to the tube and the links disengaged. The tube is then driven to the required depth.

The links are now fitted on to the cap and the cap and hammer lifted clear. The reinforcement cage carried on the skip rope is now lowered into the tube. While this is being done, the first batch of concrete is mixed and filled into the skip, which is then hoisted by the skip rope and the concrete shot into the filling hole. While a second skip is being filled, the hammer is lowered on to the tube head and the links fitted over the tube lugs.

A pull is now taken on the winch and the hammer started to work in withdrawing. The remaining three skip loads required for a twenty-foot pile are loaded into the tube in sufficient time to keep at least six feet of concrete in the tube.

The whole process, including a five-foot shift to one side, takes on an average three hours. A gang of twenty-five men can work the whole plant, including shifting, driving and mixing the concrete.

The plant can be rolled forward on its rollers by means of bars inserted into ratchet heads fixed in their ends. It can also slide sideways or be slewed round on its rollers by means of a wire rope, passing from the base of the machine out to a pulley hooked over the end of the roller and back to the capstan head on the winch.

The plant has also been fitted with road wheels. The weights of the various parts are as follows :—Base, 3½ tons ; winch, 2½ tons ; boiler, 3 tons ; jib, 3 tons ; tube, 2 tons ; hammer, 2 tons.

Mobility.—When the plant is fitted with its wheels, the jib, hammer, and tube are removed, dismantled, and carried separately.

The plant can be towed by a steam roller or tractor along metalled roads at a speed of about one mile per hour where corners, gradients or overhanging trees do not impede its progress. For short moves where a steam-roller is not available, a pulley can be fixed to trees or a hold-fast ahead of the machine and a wire rope attached to the draw-bar and passed round the pulley back to the capstan head on the winch. On unmetalled roads the plant can only be towed by a steam-roller by laying sleepers under the wheels. The progress under these circumstances is rarely half-a-mile a day.

A better method for cross-country work is to use the steam-roller as a hold-fast and attach a pulley to it. The plant can then haul itself up to the roller by means of its winch, as indicated above.

Driving.—When driving in a dry nullah bed, where three piles and one guard pile are required per bent and thirty-feet spans are being constructed, a maximum of three piles a day can be driven. Including a forward shift of thirty feet, the average drops to about

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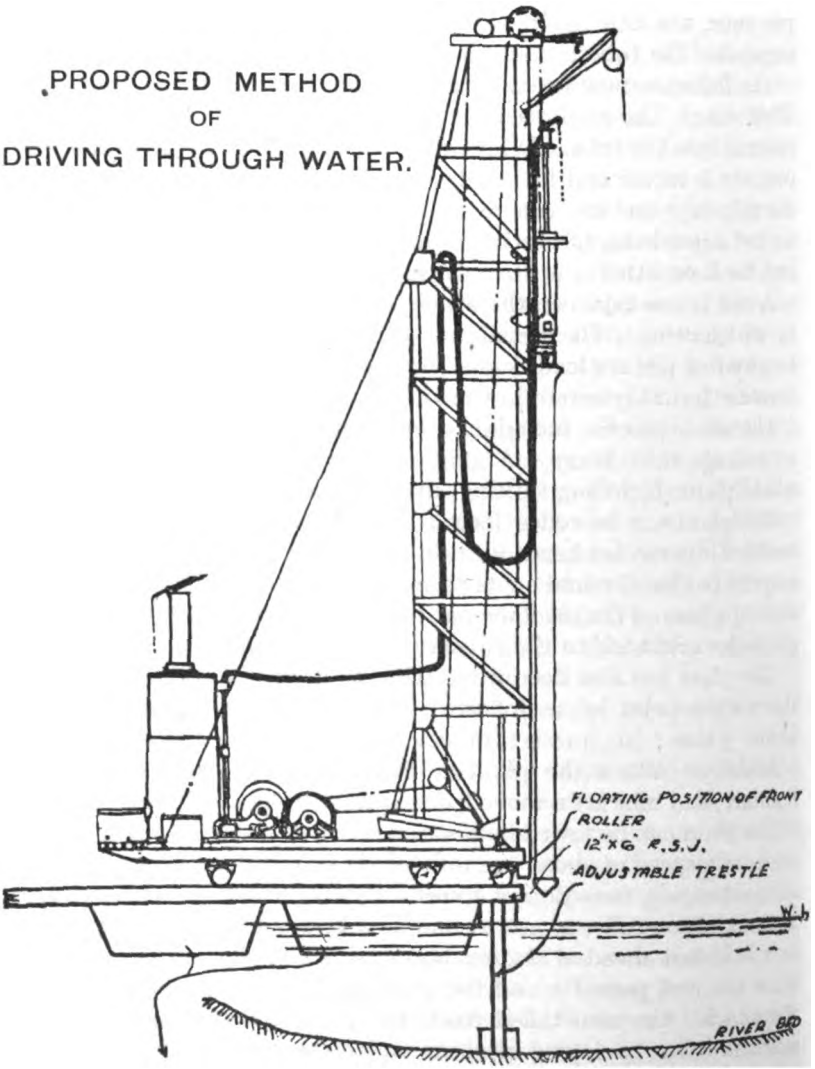
two piles a day. Allowing for breakdowns, an estimated figure of one-and-a-half piles a day may be taken. When driving through over 2 feet 6 inches of water, the plant must be floated on boats.

The method used for doing this, with the country boats available, was to fix two R.S.J's. 12″ × 6″ at 40 lb. across two boats leaving



COUNTRY BOATS.

3 feet 6 inches between them. The plant without its rollers, with its jib erected, is then slid on to the boats sideways, so that the tube can be driven between them.

The difficulty about driving from boats is to get the pile straight. Lowering the pile on to the nullah bed alters the trim of the boats, and it is not possible to moor the boats sufficiently rigidly to stop the pile becoming out of plumb if an obstruction is met while driving.

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To avoid this the following method will be tried:—Load the plant with its rollers crossways on two boats, without a space between the boats, by rolling it along them on two R.S.J's., which should project three feet beyond the boats. When the plant is floated to the site of driving, a trestle can be fixed under the projection of the R.S.J's. The plant can now be rolled forward, throwing part of its weight on the trestle. The pile can then be driven beyond it. The advantage of this method is that the boats are adequately moored.

When driving through water, great difficulty has been experienced in completing the portion of the pile between nullah bed level and water level. Up to three feet of still water, a ring of sandbags can be made, say, six feet in diameter, and an island formed by filling in with earth. Beyond this depth and in flowing water, some form of steel outer casing must be employed from a depth of three feet below nullah bed level to water level. (*Photo* 4.)

The difficulties of fixing this outer casing in position are as follows:

(*i*) It is not possible to drive a ring of any sort through a boulder nullah bed unless the hole it is to occupy is driven out by the pile shoe.

(*ii*) The casing must be completely watertight, or the flow of the water outside will withdraw the cement from inside.

(*iii*) A close-fitting casing round the pipe as required by (*i*) above can only be driven when the bulge on the lower end of the tube is removed, as it fouls the casing on withdrawing.

It is, therefore, possible to drive through water by making up a sleeve of $\frac{1}{8}$-inch sheet iron, fitting the tube closely without a bulge. This sleeve is covered by the overlap of the pile shoe and is held in position by a clip above it bolting on to the tube. The clip can be removed after the sleeve has been carried down two or three feet and the tube driven on through it.

The disadvantages of this method are that—

(*i*) The reinforcement of the pile is only covered by a minimum thickness of $\frac{3}{4}$-inch of concrete: this might be overcome by threading washers on to the reinforcement bars.

(*ii*) The section of the pile is reduced from seventeen inches to sixteen inches diameter.

(*iii*) The hole is not smoothed out so well by the bulge and it is not considered that so good a pile would result.

Many other experiments were tried to overcome this difficulty, but without success.

Piles.—The vibro-concrete piles for these bridges were driven to a minimum depth of seventeen feet below maximum nullah bed level, and the legs had a maximum height above n.b.l. of sixteen feet.

The outer diameter of the vibro pile is seventeen inches, and the reinforcement used consisted of six $\frac{3}{4}$-inch longitudinal bars, with $\frac{1}{4}$-inch hoops spaced at two-foot intervals. (*Photo* 5.)

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The maximum axial load that can be carried by such a pile is forty-eight tons, allowing a maximum stress of 500 lb./in.² in the concrete and calculating for concrete inside the reinforcement only.

Eccentric loading.—If the load of W tons falls one inch eccentrically on the pile a bending moment of W in. tons will be set up.

$$\frac{{}^{r}b\,I}{y} = W$$

where $I = \frac{d^4}{20}$. $Y = \frac{d_2}{2}$. ${}^{r}b$ = stress in concrete due to bending.

Assuming that the d, including the reinforcement may be taken as $16\frac{1}{2}$ inches and $d_2 = 14\frac{1}{2}$ inches.

$${}^{r}b = \frac{W \times \frac{14\frac{1}{2}}{2} \times 2240}{(16\frac{1}{2})^4/20} = 4{\cdot}5\ W \text{ lb./in.}^2 \text{ per inch of eccentricity.}$$

Stress in concrete due to direct load $= \frac{W}{48} \times 500 = 10{\cdot}4\ W$ lb./in.².

Temperature stresses in the legs.—Allowing for a change of temperature of $\pm$ 25° F. the movement in a forty-foot span will be

$$\pm\ {\cdot}0012 \times \frac{25}{180} \times 40 \times 12 \text{ in.} = {\cdot}08 \text{ inches.}$$

Deflection of leg $= d = \frac{P^3}{3EI}$. Bending moment $= Pl = \frac{{}^{r}dI}{Y}$.

Stress due to deflection. ${}^{r}d = \frac{PlY}{I} = \frac{3EId}{3}\frac{ly}{I} = \frac{3Edy}{2}$.

Where l = 15 feet.
E = 2×10^6 lb./in.².
d = ·08 in.
$Y = \frac{14\frac{1}{2} \text{ in.}}{2}$.

$${}^{r}d = \frac{3 \times 2 \times 10^6 \times {\cdot}08 \times 7{\cdot}25}{15^2 \times 12^2} \text{ lb./in.}^2.$$

$= 107$ lb./in.².

Safe load on leg.—Allowing a maximum stress of 500 lb./in.² in the concrete, one inch eccentricity of loading and a temperature movement due to one span

${}^{r}w + {}^{r}b + {}^{r}d = 500$ lb./in.².
$10{\cdot}4\ W + 4{\cdot}5\ W + 107 = 500$ lb./in.².
$W = \frac{393}{14{\cdot}9}$ tons.
$= 26$ tons.
${}^{r}w = 274$ lb./in.².
${}^{r}b = 119$ lb./in.².
${}^{r}d = 107$ lb./in.².
500 lb./in.².

The set on finishing driving was never more than ·2 inches. The makers of the plant give 150 tons as the failing load for this set. This gives a factor of safety of six.

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On a forty-foot span, as was used at Khiali, the weight of the R.C.C. T beam decking was 1·8 tons per foot run, or 73 tons per span. The live load may be taken as thirty tons dead load per span, totalling 103 tons.

Four legs were therefore required—the load on each being twenty-six tons—and the maximum stress in the concrete—500 lb./in.^{2}.

Expansion joints.—As has been shown above, the maximum stress allowable in the concrete due to temperature movement is 107 lb./in.^{2}. This will give a horizontal pull in the transom of P lb. per leg where $f_d = \frac{Ply}{I}$.

$$P = \frac{107 \times 16\frac{1}{2}^4}{15 \times 20 \times 7{\cdot}25 \times 12} = 300 \text{ lb.}$$

$f_d = 107$
$l = 15' \times 12\cdot$
$y = 7{\cdot}25$
$I = \frac{16\frac{1}{2}^4}{20}$

The allowable pull on the pile bent at transom level is therefore 1,200 lb. per bent.

It was originally intended to give a steel plate sliding joint on every other span. If the co-efficient of friction be taken to vary from ·25 to ·60 for an unrusted-up joint to a rusted-up joint, the difference in pull on the transom will be ·35 × 36 tons = 13 tons.

This is obviously out of keeping with the allowable pull on a transom and the idea was abandoned.

Rollers for similar reasons were also ruled out. The design finally adopted was to break the bridge completely after every sixth span.

The three centre legs were sixteen inches six-sided reinforced concrete columns with six $\frac{3}{4}$-inch bars carried through in continuation of the vibro concrete piles.

The two legs outside these were " point supported legs " (Fig. 1). The method used for these was to mould a ground transom on the heads of the vibro piles. The leg reinforcement was then all bent into the centre-line of the transom. Extra bars were added in order to provide enough iron for the whole of the weight to be carried in the reinforcement. A layer of bitumen was laid between the bottom end of the leg and the ground transom, to protect the reinforcement and to allow for the movement of the leg.

The two outside bents of the six spans, carrying a half span load only, were constructed of R.S.J's. 12″ × 5″ at 30 lb. with a 4″ × 3″ T bolted down the web: the main axes of the R.S.J's. were at right angles to the line of the bridge (Fig. 2).

The top end was rigidly moulded into the T beam and the bottom end moulded into a ground transom and also bolted to the similar R.S.J. at the end of the next six spans which shared the same pile bent with it. A set of three legs per bent was used.

Calculations for R.S.J. legs.—The maximum movement in three spans will be ± ·24 in. $= d = \frac{Pl^3}{3EI}$.

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where l = length of R.S.J. leg acting as a cantilever—
= say seven feet for a nine-foot leg.

The stress due to the force P is given by—

$$Pl = {}^{r}d\, I/y$$

$$^{r}d = \frac{Ply}{I} = \frac{d.\ 3EIy}{l^3}\ \frac{ly}{I} = \frac{3Edy}{l^2}$$

Where $E = 30 \times 10^6$
$d = \cdot 24$
$y = 5/2$
$l = 7 \times 12$
$^{r}d = 7{,}500$ lb./in.^{2} $\qquad W = 73/6 + 30/3 \times 3/4$ tons.

$$^{r}w = W \times \frac{2240}{A}\ (l - \ddagger\ (l/r)^2)\ A \left.\begin{matrix} = 8\cdot 3 \\ + 2\cdot 5 \end{matrix}\right\} \text{square inches.}$$

$= 6{,}350$ lb./in.^{2} $\qquad \ddagger = \dfrac{1\cdot 95}{25{,}000}$

$r = 13{,}850$ lb./in.^{2} $\qquad l = 7 \times 12$ in.

Four R.S.J. legs are required. $\qquad r = 1$ in.

Eccentricity of loading of legs.—It has already been shown that the stress set up in the pile by one inch eccentricity of loading amounts to 119 lb./in.^{2} per inch of eccentricity.

When driving piles, the head of the steel tube is held in to the jib, but when a large boulder is struck, say, up to six feet below ground level, the point may move sideways through the ground a matter of six inches. This can be rectified by overshifting the plant beyond the vertical, driving on another five or six feet and then shifting the plant back again to the vertical during the course of driving. If the boulder is met below six feet, it will not be possible to correct the pile completely, but the movement will not be so great in this case.

When driving from boats moored by ropes, the movement was found to be much greater, and the correction much less successful. This would, however, be partly corrected by using a trestle as indicated previously. The result of this is that a maximum slope out of the vertical of three inches or a horizontal displacement out of line of three inches may have to be catered for in the worst case.

It is, therefore, considered advisable to mould a ground transom 18″ × 22″ over all bents the piles of which were more than one inch out of line, and for all bents where R.S.J. or "point-supported" legs were used. The legs were then built in a straight line along the ground transom, which had to be strong enough to take a twisting couple of, say, dW in. tons

where d may be taken as two inches

and $W = \dfrac{103}{4}$ tons $= 26$ tons.

Couple $= 52$ in. tons

if the effective mean depth and width of the transom be taken as

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FOR KHIALI BRIDGE
ENTS Nos 5 & 13

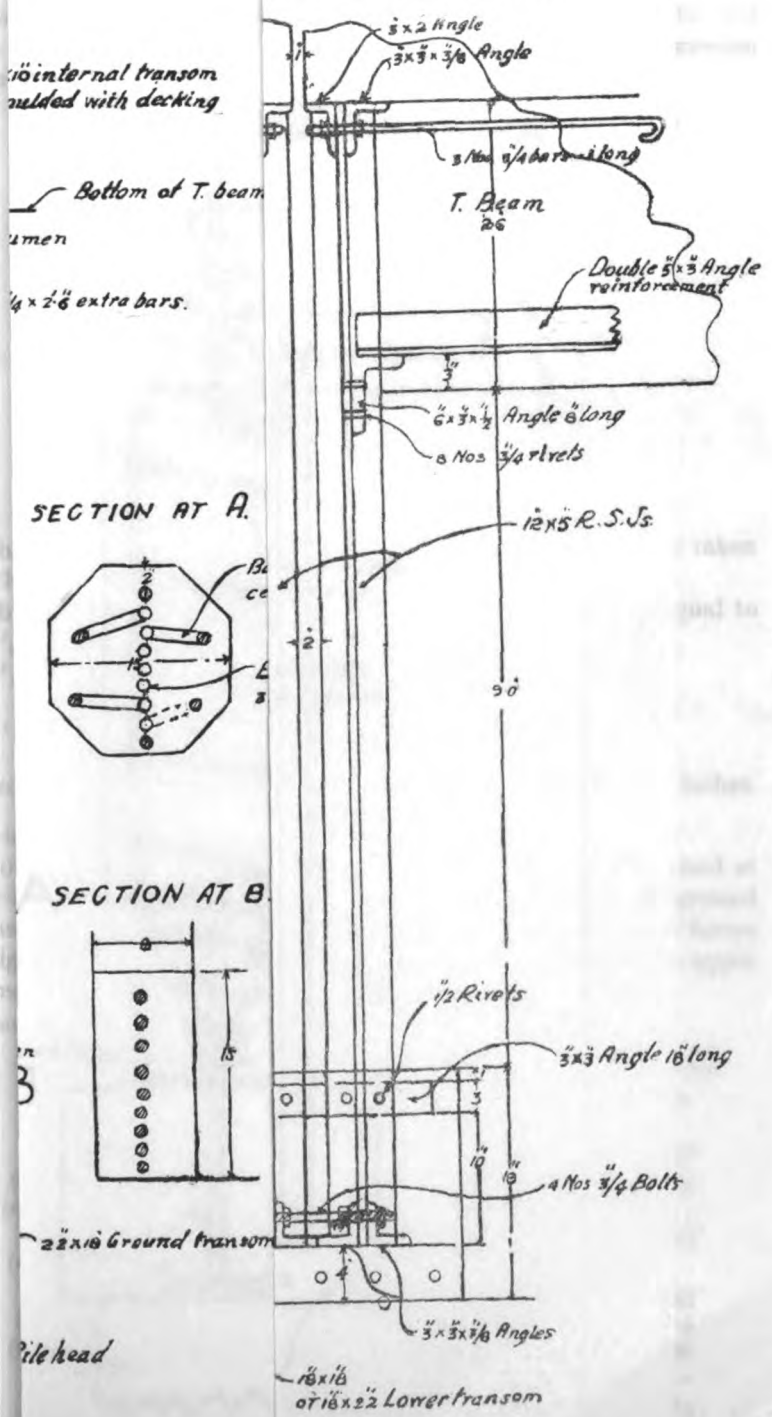

Fig. 2.

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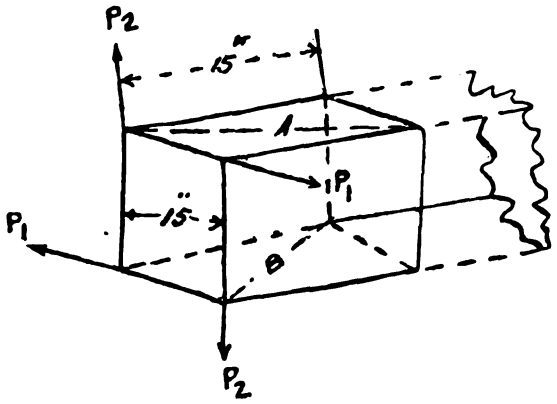
sixteen inches and a sixteen-inch length of the transom be considered. The faces A and B act as two girders in which the full lines are tension members and the dotted lines are compression members.



The latter can be taken by the concrete, the former must be taken by the reinforcement.

The couple acting on these two faces is P_1 P_1 which is equal to P_2 P_2.

$(P_1+P_2)b = 52$ in. tons.

$$P_1 = P_2 = \frac{52}{30} \text{ tons} = 1{\cdot}7 \text{ tons.}$$

Section of steel required is $\frac{1{\cdot}7}{7{\cdot}5}$ square inches $= {\cdot}23$ square inches.

½-inch bar hoops at twelve-inch centres will do.

To give additional stiffness, however, ½-inch bars were used at four-inch centres, and four ¾-inch bars longitudinally in the ground transom. Where ground transoms were not used, ½-inch bar hoops at eight-inch centres with four ¾-inch bars were fixed in the upper transoms.

Cost of driving piles per bent—

		4 piles and 1 guard pile. Rs.	3 piles and 1 guard pile. Rs.
(1)	(*i*) R. C. concrete work in vibro piles	370	278
	(*ii*) R. C. concrete in legs ...	270	155
	(*iii*) R. C. concrete in two transoms	223	223
	(*iv*) Driving piles in dry nullah bed at 1½ piles per diem	167	133
	(*v*) Piles shoes	130	104
	(*vi*) Contingencies 10% ...	110	90
		1,207	983

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Cost of driving piles per bent—	4 piles and 1 guard pile. Rs.	3 piles and 1 guard pile. Rs.
(2) Add for driving in water ...	167	133
(3) Add for sleeves where water exceeds three feet ...	150	120
(4) Add for twenty-one inches C.I. pipes nine feet long, with shoe	900	720
(5) Add for driving from boats ...	50	40
(6) Add for depreciation of piling plant calculated at a life of 1,000 piles	200	160

Cost of decking per foot run—	40-*foot span.* Rs.	30-*foot span.* Rs.
(1) Slab only with hand rails ...	40	40
(2) T beams without main reinforcement	40	26
(3) Main reinforcement	15	11
(4) Contingencies, 10 per cent. ...	10	8
	105	85

Cost of bridging.—The cost of bridging per foot run for an eighteen-foot width roadway works out from the figures above as under :—

	40-*foot spans.* Rs.	30-*foot spans.* Rs.
(1) Bridging in a dry nullah bed without C.I. casings	140	123
(2) Bridging in the presence of water using $\frac{1}{8}$-inch sleeve casings ...	150	133
(3) Bridging in the presence of water using C.I. casings	168	153

Note.—By using R.C.C. slabs on R.S.J.s on the thirty-foot spans the cost can be reduced by Rs. 5 per foot run.

The above quoted figures do not include the cost of abutments, approaches, training works, accommodation for labour, cost of bringing the plant to site of work, carriage of materials, etc.

On the Kabul and Swat rivers for each bridge these items may be taken as roughly Rs. 35,000. For a 700-foot bridge such as is being constructed at Khiali, this works out to Rs. 50 per foot run.

Economical span.—In calculating the most economical span for these bridges the waterway should be considered rather than the over-all span; this may be taken as four feet less the over-all measurement, allowing two feet for the guard pile and one foot for the swing of the water away from the bent on each side. The most economical span lies obviously in the neighbourhood of thirty feet.

Using R.S.J's. to carry the decking, the choice falls between three 20″ × 6½″ at 65 lb. and three 22″ × 7″ at 75 lb. The load to be carried is 18 [190 — 4 (x — 30)] lb./feet run, (*M.E.S. Handbook*, page 50) the clear span is X feet.

The weight of the decking and girders is 2,400 lb. per foot run plus 3 × 65 for three 20″ × 6½″.

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KHIALI BRIDGE.

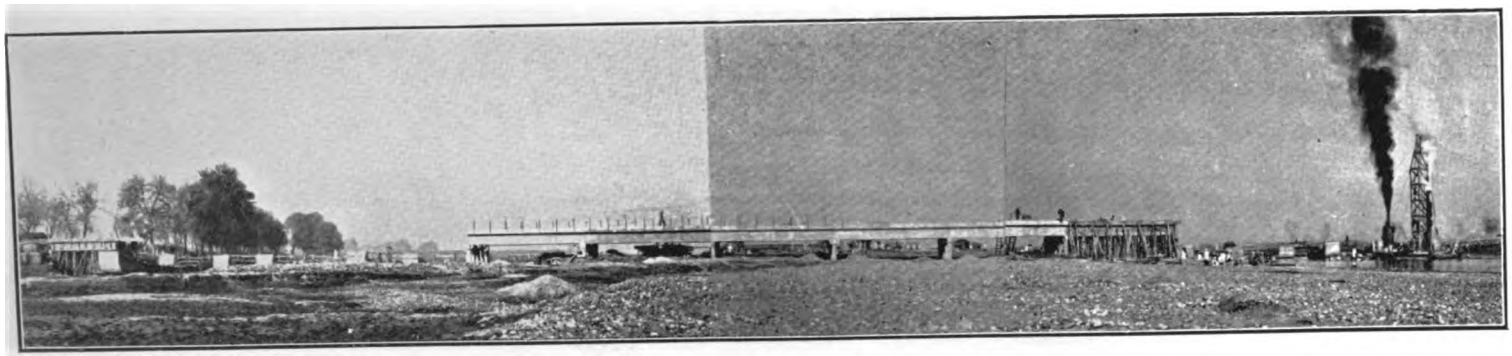

PHOTO 1.—Panorama, on 22. 12. 28, from downstream. Bay No. 1.—Centring in position. Nos. 2, 3, 4 and 5, piles driven. Nos. 6 to 11, decking complete, piles being driven on No. 15 bent. The boat bridge can be seen in the background.

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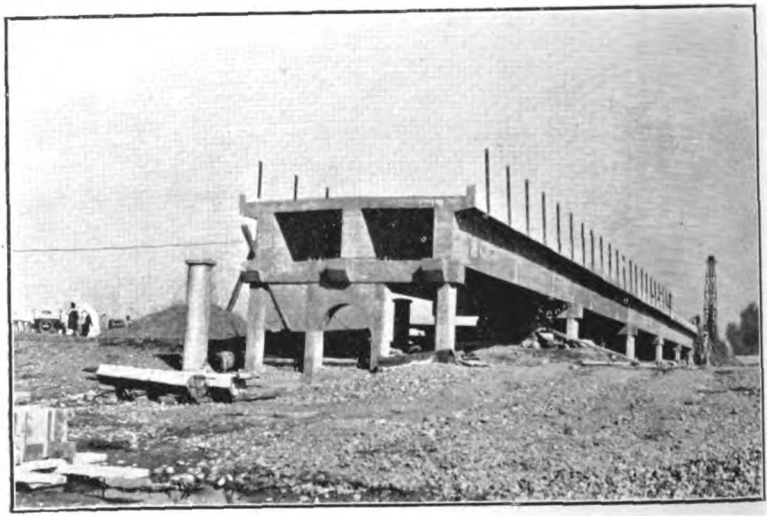

PHOTO 2.—End view of No. 6 bay, showing general arrangement of pile bent and guard pile.

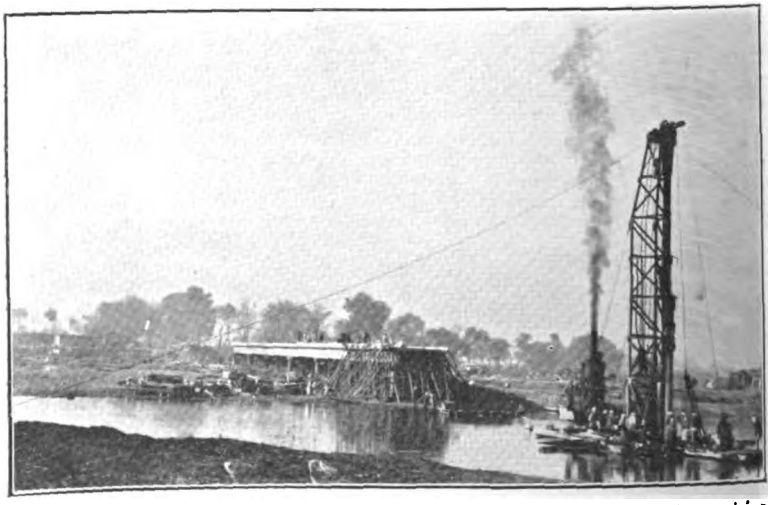

PHOTO 3.—General view from left bank, 22. 12. 28, showing shoring for centring of No. 11 bay.

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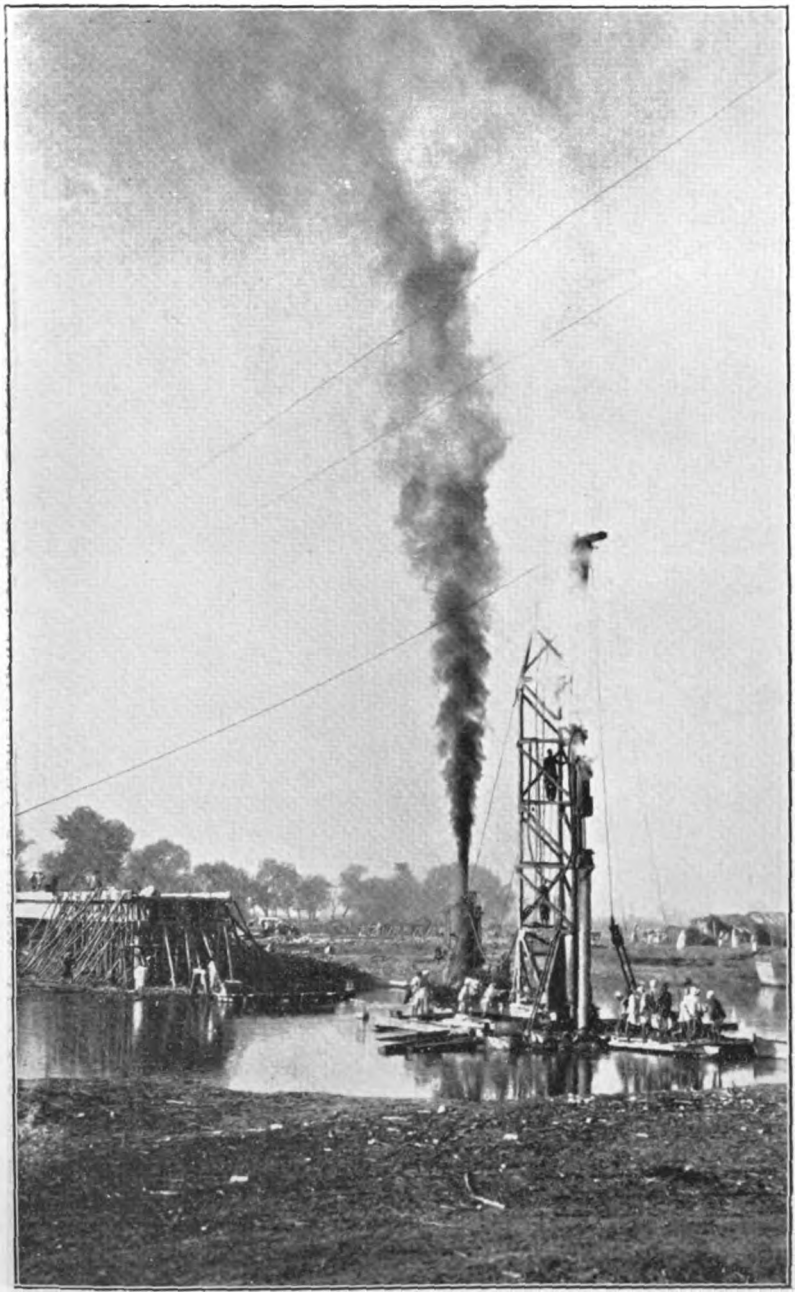

PHOTO 4.—Pile driver, working on bent No. 15, driving piles below the bund, through artificial island formed of boulders in trungas wall filled with earth inside. Depth of water, 4 feet.

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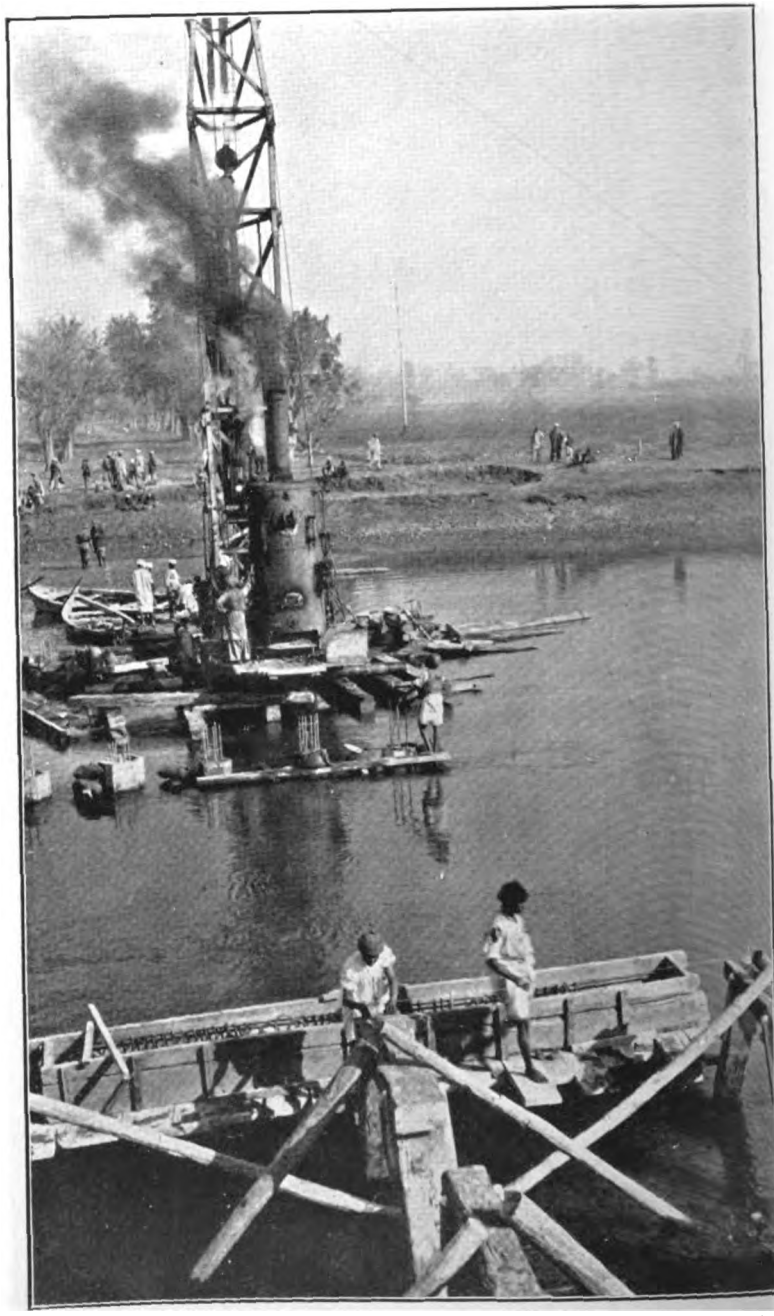

PHOTO 5.—The right hand of photograph shows a ground transom being moulded on to the pile heads of bent No. 13. The pile heads, with reinforcement sticking out, can be seen in bent No. 14.

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The total load is therefore (8,175 — 72x) lb./feet run. Maximum load per girder is (2,725 — 24x) lb./feet run.

Maximum bending moment $= \frac{wl^2}{8} = \frac{(2{,}725 - 24x)X^2}{8}$

Moment of resistance of 20″ × 6½″ $= \frac{16{,}000 \times 122{\cdot}6}{12}$

$(2{,}725 - 24x)x^2 = \frac{8 \times 16{,}000 \times 122{\cdot}6}{12} = 1{,}307{,}700$

When $x = 20$. L.H.S. = 898,000

$x = 25$. L.H.S. = 1,353,000

Maximum span $= 25$ feet $+ \frac{130 - 1{,}353}{1{,}308} \times 45$

$= 25 - {\cdot}5$ $\qquad = 24{\cdot}5$ feet $- \frac{1{,}353 - 898}{1{,}308}$

Using three 22″ × 7″ girders at 75 lb.

load per girder 2,735 — 24x lb./feet run.

Moment for resistance $= \frac{16{,}000 \times 152{\cdot}4}{12}$

Maximum span = 28·0 feet.

Using 24″ × 7½″ at 90lb.

Load per girder = 2·750 — 24x

M. of R. $= \frac{16{,}000 \times 203{\cdot}6}{12}$

Maximum span = 33·4 feet.

The comparative costs work out as below—

Girder	22″ × 7″	24″ × 7½″	T. beam.
Weight	75 lb.	90 lb.	...
Clear span	28 feet	33·4 feet	28 feet
Over-all span	30 feet	35·4 feet	30 feet
Waterway	26 feet	31·4 feet	26 feet
Cost of decking per foot run of bridge	Rs. 49	Rs. 48	Rs. 44
Cost of bents with C.I. casings per foot run of bridge	Rs. 68	Rs. 56	Rs. 68
Cost of girders per foot run of bridge	Rs. 30	Rs. 36	T. beams Rs. 41
Total cost per foot run of bridge ...	Rs. 147	Rs. 140	Rs. 153
Total cost per foot run of waterway . with C.I. casing driven in water	Rs. 171	Rs. 162	Rs. 178

As it is necessary to make use of the boat bridge decking for a period on top of the trestles, until funds are allotted for the concrete decking, bents must be constructed at thirty-foot centres and 22″ × 7″ girders used.

The load per bent with these R.S.J's. is 35 tons dead load *plus* 30 tons live load, including impact factor 65 tons, or 23 tons per pile.

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SOME NOTES ON STEEL SLEEPERS.

By LIEUT. I. L. H. MACKILLOP, R.E.

STEEL sleepers have been extensively used by railways abroad for some considerable number of years past, but their adoption, in any quantity, by the home railways has been delayed until this year. The reason for this delay may be partly conservatism, and partly the difficulty of producing a satisfactory design, having regard to the high standard of permanent way practice in this country, but is chiefly due to the plentiful supply of cheap timber which has been available.

Although the railway companies have decided that a portion of the 1930 re-laying programme shall be carried out with steel sleepers, the design is still in the experimental stage, and no type has been laid down as a British standard.

There are, however, two outstanding types :—

Type I consists of a plain steel sleeper, with a cast-iron chair, cast on to the sleeper, being held on by four snugs. Fig. I shows this design ; it is known as the " Composite " steel sleeper, and it has been adopted by the G.W.R. and the L.N.E.R.

Type II consists of a steel sleeper and a steel chair, the latter being formed by stamping and bending up a portion of the top of the sleeper, and by inserting another piece of plate to form the rail seating. Fig. II shows this design; it is known as the " Sandberg " steel sleeper and has been used in small quantities by the S.R. since 1921.

Comparing the two types, the second appears to have the disadvantage of weakness, owing to some of the metal in the sleeper being utilized to form the chair jaws ; moreover, this metal is taken from the place where most needed, *i.e.*, directly under the rails. An additional disadvantage is that the chair is composed of two pieces which tend to become loosened under traffic, whereas Type I, being all one piece, is not subject to this failing and overcomes the objection of " noisy running," which has been raised against steel sleepers.

With regard to cost, Type II compares favourably at 15s. 3d. per sleeper against 16s. 3d. for Type I ; if the comparison is made by weight, Type I shows an advantage of £7 per ton against £10 for Type II. This may not appear an advantage at first sight, since

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requirements for a length will be a certain number of sleepers and not a certain weight, but, as will be seen from the diagrams, Type I is a heavier sleeper, and the scrap value, being approximately proportional to the weight, is higher; it should also be noted that a heavier sleeper gives better running.

As has been already stated, the design is still experimental; the outstanding difficulty is how to pack the sleepers satisfactorily when they have been laid. In fact, there is some money to be made by anyone who can solve the problem. To those who are thinking that here is a chance to do this, a few remarks on what has already been done may be of use. There is no special difficulty in packing the sleepers when they are first laid, but when they have been down about a year the bed underneath tends to get consolidated, and it is then that the difficulty arises.

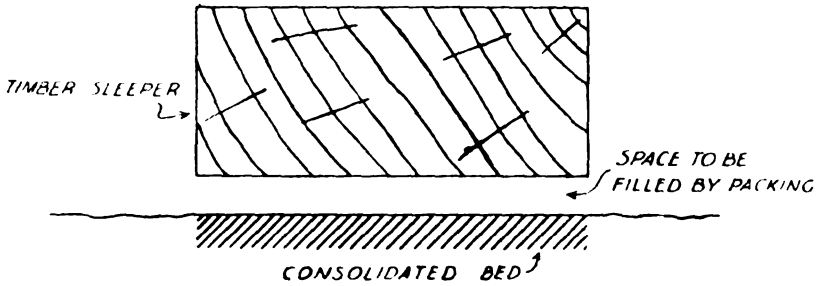

FIG III (a)

For example, let us suppose that, in order to remove a slack (*i.e.*, low place) in one of the rails, a lift of 1 in. is required. The track is lifted by jacks the required amount; ballast must then be placed between the top of the bed and the bottom of the sleeper.

The sketch (Fig. III (a)) shows clearly how this is easily done in the case of a timber sleeper, either by forcing in the ballast with a beater pick or by shovel packing.

The sketch (Fig. III (b)) shows the position with a steel sleeper. Shovel packing is practically impossible, and the use of beater picks is unsatisfactory, because, although ballast can be beaten in at the bottom, thus forcing the bed up against the underside of the sleeper, the bed will be disturbed and settlement will ensue. Moreover, this is not in accordance with the principle of placing the packing between the sleeper and the top of the consolidated bed.

A method is being tried in which four holes are cut in the top of the sleeper, one on either side of each chair; the packing (either sand or small chippings) being poured in through the holes. To enable this to be done satisfactorily the holes require to be 2½ in. to 3 in. in diameter, and close up to the chairs (*i.e.*, where the load

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will come). Holes of this size so situated, however, considerably weaken the sleeper and are undesirable; it has been found experimentally that holes up to 2 in. diameter do not seriously affect the strength of the sleeper, and the possibility of packing through a 2-in. hole is now being tried out.

Another suggestion has been to leave the ends of the sleepers open, and to pack through the ends. The turned-down ends of the sleeper, as designed at present, bite into the ballast and prevent side movement; if, therefore, the ends are not turned down, some other device must be provided to keep the track in line. With this in view, it has been suggested that two gussets, or stiffeners, should be welded into the underside of the sleeper, placed 12 in. to 15 in. inside the rail, one on either side of the centre line. These plates would be in a vertical plane and be parallel to the rails; they would thus bite into

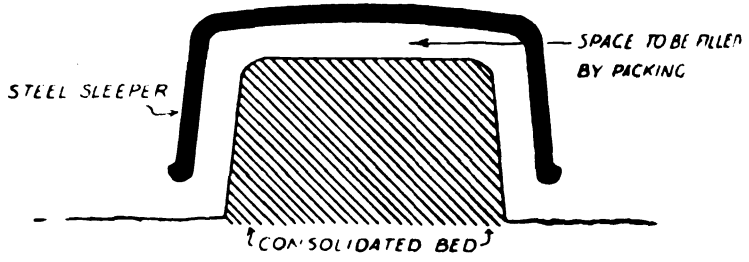

FIG III (b)

the ballast and prevent movement, and still leave the ends open for packing. The objection to this idea is that it involves an extra operation in manufacture and thus increases the cost of production; it is also stated that end packing would tend to cause the sleeper to sag at the centre.

Turning to the comparison of steel and timber, the following points are of interest:—

(1) *Cost.* For similar quality material, steel sleepers cost 1s. to 1s. 6d. more per sleeper.

(2) *Life.* The life of a steel sleeper is computed at 30 years, as against 20 to 25 for timber.

With regard to cost, the increase in scrap value of the steel sleeper more than discounts the increase in original cost. When considering the cost of maintenance, British engineers have, so far, worked on the assumption that both are equal; this remains to be proved.

With regard to life, some difficulty has been experienced with corrosion and consequent wasting of the metal, in ash or slag ballast, in marshy ground, or in localities in the neighbourhood of chemical

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and other works which contaminate the air with gases of a sulphur base. This shortens the life of the sleeper, but it can be overcome, to some extent, by the addition of ·25 per cent. of copper. The extra cost of this is about 7d. per sleeper.

There is one other consideration when making the comparison, and that is when the provision of insulation for electric traction or for track circuiting is required. These requirements present a problem, not by any means insoluble, but one the solution of which will undoubtedly involve an increase in cost.

While on the subject of track circuiting, it is interesting to note that the German railways, which use steel sleepers very extensively, have adopted a new idea and are developing the use of a silenium cell in this connection. The principle is similar to that now in use for timing high speeds. It utilizes the fact that when a ray of light, playing on a silenium cell, is interrupted, the interruption induces a small current in the cell. It is easy to see how this current may be relayed up to perform the same functions as the present track circuit currents; the ray of light, in this case, is interrupted by a train occupying the length of track in question.

Generally speaking, from the technical and commercial aspect, it may be said that there is little to choose between timber and steel, and there appears, therefore, small reason for the change.

While the technical aspect may be indifferent to the adoption of steel, the political and economical is strongly in favour. One of the reasons, in fact the chief reason, mentioned at the beginning of these notes for the tardiness of the British railways in using steel sleepers, was the plentiful and cheap supply of suitable timber. In the appendices to the summary of the proceedings of the Imperial Conference, held in 1926, reference, at some length, was made to the "world's timber position." It is significant that serious consideration of the use of steel sleepers commenced in the same year. A few short extracts from the reference will be of interest :—

"(1) A review of the forestry situation throughout the world leads to the conclusion that available supplies of the principal timbers of commerce are rapidly approaching exhaustion. There is every likelihood that in less than 30 years a shortage of soft woods will be severely felt.

"(2) Apart from wood used for fuel, 80% of the world's demand is for soft woods, *i.e.*, pine, spruce, larch and fir.

"(3) In Europe, except Russia, the consumption of soft woods exceeds the growth by 3,000 million cubic feet annually.

"(4) In Russia and Siberia vast areas of soft wood forest exist, but they are so remote from communication that *until the price of timber rises* they will not be an economic source of supply.

"(5) It is estimated that in U.S.A. and Canada there is barely 25 years' supply at the present rate of consumption."

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It is apparent, therefore, that the price of timber will gradually rise, and as it rises so will the case for steel sleepers improve.

The U.S.A. consume approximately half the world's timber, and as supplies naturally tend to go to the nearest consumer we obtain practically all our timber from Russia. To be dependent on outside sources for an essential raw material is undesirable, and the situation is not improved when the sources are narrowed to one only. The position is fully realized in this country and efforts are being made, in all directions, to find suitable substitutes for timber; steel, being an entirely home product, is foremost among them.

One of the items in the programme outlined by the present Government in their campaign at the last election was the solution of the unemployment problem. Material assistance would result from the return to their pre-war status of our staple industries. The outlay by the home railways on permanent way material is in the neighbourhood of £7,000,000 annually, a considerable portion of which is expended on sleepers. The addition of this portion to the turnover of the steel trade would be an appreciable step in the right direction; so much so, that the Government are pressing for the general use of steel sleepers. In fact, many conservative railwaymen, when asked for an opinion, say that it is the Government, and not the railways, who are responsible for the present movement in favour of the use of steel sleepers.

Suffice it to sum up that all concerned are agreed that a substitute for timber is desirable and that steel is suitable.

Many articles and papers have been recently written on this subject, and no apology is made that the majority of the facts and information in these notes have been extracted therefrom, but few, if any, have touched on the military aspect. Not being limited by the somewhat elastic space of "one short hour" some considerations, from this point of view, are added:—

(1) The suitability of steel sleepers for military railways.
(2) The sources of supply in event of war.

The 75-lb. B.S. flat bottom rail is the accepted type for military railways. Steel sleepers of both the Composite and Sandberg types to suit this rail are already in commercial production. While Type I appears to be more suitable for civil railways in this country, Type II (the Sandberg), having the advantage of lightness, will be favoured for military use. It is of the utmost importance to keep the weight of military permanent way down to a minimum, not only to facilitate handling in track laying, but also to enable store ships and construction trains to carry the maximum length of track. The Sandberg design, suitable for 75-lb. flat bottom rails, is shown in Fig. 4.

The weight of this sleeper, complete with four steel keys, at 136 lb., compares well with that of a timber sleeper, complete with

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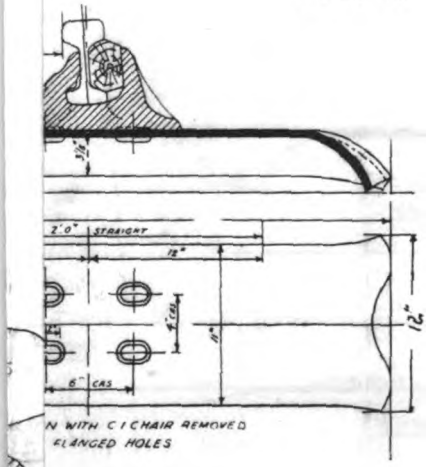
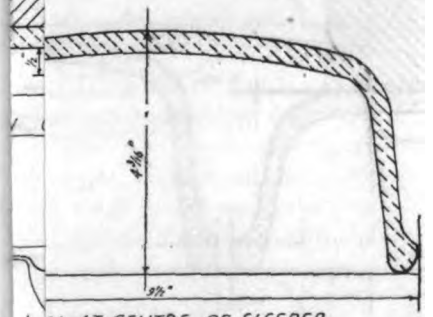
FIG I.





95 R.B.H. RAIL.

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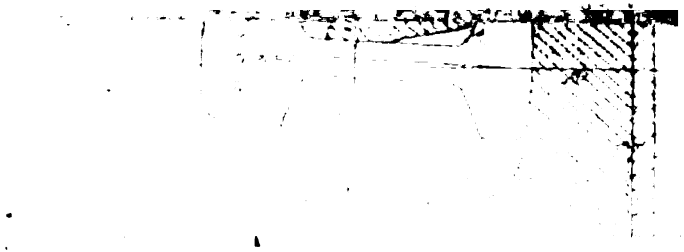

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FIG II.

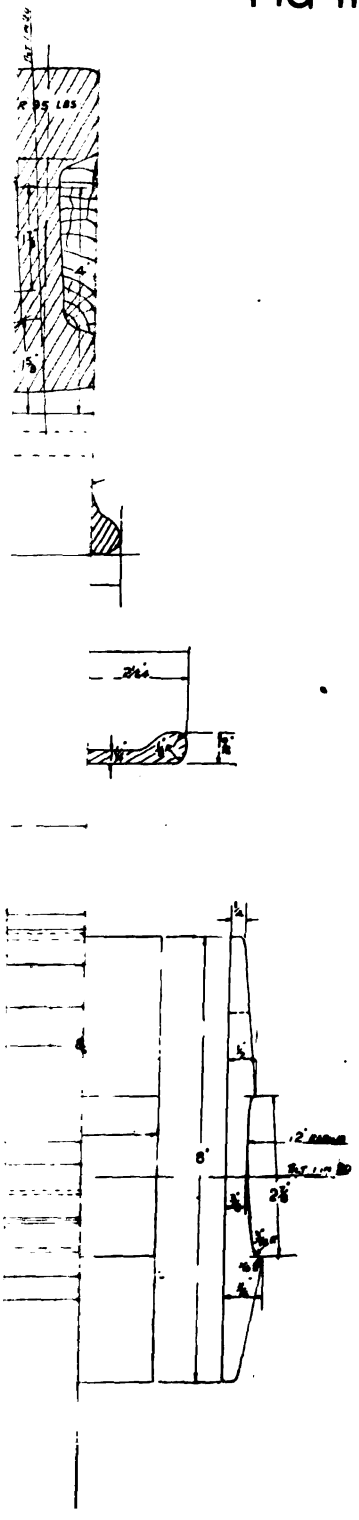

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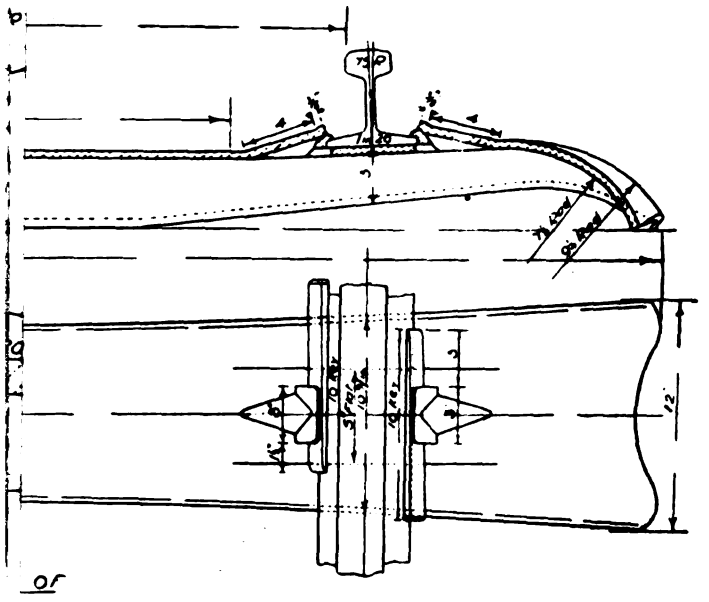
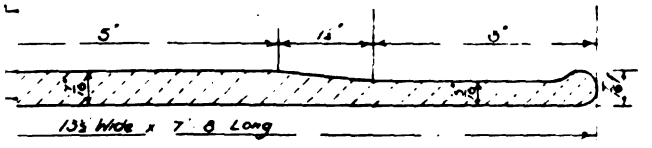
FIG IV.



of



of PLATE (UNPRESSED)

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two bearing plates and six spikes, at 134½ lb. uncreosoted, or 162½ lb. creosoted.

The use of taper steel keys should be noted; on military railways where sharp curves are frequent, it is normal practice slightly to widen the gauge in order to ease the passage of long wheel-base vehicles. This is very simply done by loosening one key and tightening the other, the gauge being variable within the limits of key taper. Further, in event of an adjustment of gauge being required for any reason a timber sleeper has to be re-spiked; constant re-spiking is undesirable as the re-driven spikes do not hold well on account of old spike holes. On the other hand, the gauge may be adjusted any number of times with no detriment to steel sleepers.

The design shown does not include the separate plate required in the case of bull-head rails, nor are the chair jaws so large, consequently the disadvantages of loose parts and weakness pointed out earlier in the notes do not apply for flat bottom rails.

A consideration of importance is that of "end on" plate-laying. Since there is no spiking to be done, it is estimated that a reduction of at least 50 per cent. can be made in the rear party.

The question of fittings (*i.e.*, switches, leads, crossings, etc.) with steel sleepers has not yet been solved by the civil railways; it is a difficult one; and it is aggravated in the case of military railways by the need for standardization of parts and the reduction of specials to a minimum. For the present, we must curtail our thoughts to the use of steel sleepers in plain line.

The question of the supply of steel sleepers in event of war presents little difficulty, and is perhaps the most compelling reason for their adoption for military use.

Steel sleepers are produced from start to finish in this country; by using them, therefore, we can release cargo space, previously used for bringing timber into the country, for other urgent commodities, and we are not dependent on an outside source of supply. As stated previously, designs suitable for military railways are now in commercial production, immediate supplies should, therefore, be available when required.

It has been shown that a timber shortage is imminent, and it may become essential to restrict the use of timber to necessities.

The writer ventures to express a hope that the authorities concerned will try and see their way to provide a small quantity of steel sleepers, to enable railway troops to become familiar with their use, and to settle upon the most suitable type.

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SOME R.E. PROBLEMS IN AIR DEFENCE.

By CAPTAIN L. E. C. M. PEROWNE, R.E.

*" We can set our defence organization the exact problems it will have to solve in war . . . the handling of the searchlights and the system of control are the same in peace and war . . . and our peace manœuvres . . . will give us a very clear idea of how far we are progressing towards a solution."**

THE appearance of the new Manual, which is now in course of preparation, consolidating, as it were, the ground made up to the present day, will constitute a distinct milestone in the history of air defence. The object of this article is to review at this stage the extent to which our difficulties are already met ; to define afresh the R.E. problems in air defence towards the solution of which we must continue research and to suggest a possible line of development for the future.

(A) " . . . *the handling of the searchlights* . . . "

(i) *General.*

The role of an R.E. unit in air defence is one of co-operation, either with fighting aeroplanes or with anti-aircraft artillery. The primary function of searchlights is the illumination of hostile aircraft. When clouds obscure the target, this function is held to have been discharged if three beams are accurately directed by sound, so that (if produced beyond the clouds) their intersection would indicate to defending aircraft the position of the enemy.

The Air Defence of Great Britain exercises may be taken as fairly conclusive tests as they reflect the work of both Regular and Territorial units. An official report on the 1927 Exercises states that many day raiders got through unattacked (in the aircraft fighting zone), but, " on the nights when exercises were carried out, no bomber which actually came over the lights was able to escape our fighters."†

The result of six weeks' continual nightly practice in 1928, culminating in A.D.G.B. manœuvres that year, bore out this assertion.

From the foregoing statement, backed by the experience acquired during five years of constant practice, it can be affirmed that, at the present stage of development, given trained men working together

* Major-General Ashmore, *Air Defence*, p. 145.
† These nights were admittedly easy for the defence.

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for a season, no hostile aircraft should escape detection and illumination (as defined above) when passing over a lighted area* in any weather or at any height at which it might hope to make profitable bombing practice.

The weather, being beyond our control, requires but brief consideration. In general, it may be accepted that weather which is favourable for the attack is equally so for the defence and *vice versa*. On moonlight nights, when the ground lies clearly visible to the airman, silhouette spotting renders the task of locating him simple. When ground mist prevents those at the searchlights from seeing anything in the air, the land lies densely shrouded from the attacker's view. On such occasions it has been found good tactics not to expose the lights at all and so to leave the enemy in ignorance of his whereabouts.† When low clouds obscure the target from view from the ground, beams penetrate to a great height and can be seen by friendly pilots also above the clouds; while by flying at a greater height than that of the attacker, the raider may be seen in silhouette against the clouds lit up generally by the beams from beneath, even if they are not being directed accurately at the enemy. At twenty miles, and even twice this distance under favourable conditions, defending pilots have been able to detect suspicious concentrations of beams indicating the presence of an enemy.

The competition between beam range and flying height provides the parallel to the eternal struggle in naval warfare between gun and armour. With a range under average weather conditions of five or six thousand yards along the beam, the M.C.D. equipment has within reach machines flying at heights up to twelve thousand feet. At the present stage of development it is questionable whether effective bombing on a large scale can be carried out at heights much above ten thousand feet, while experience in the War showed that, over sixteen thousand feet, the physical effects alone on the crews of the Zeppelins were so great as to reduce their striking power almost to vanishing point.‡

Research has, however, so far developed that, with the introduction of the H.C.D. lamp, machines travelling at the great heights of twenty thousand feet and above are brought within range of illumination from the ground. So that for the present, at any rate, the defence is in this respect well in advance of the attack. But in order to simplify spotting and to counteract the effects of the protective colouring of aircraft, as well as for gunnery purposes, as much light as possible, under all conditions, is required on the target, and

* The equipment referred to in the consideration of progress made up to the present time is the standard 90-cm. projector with M.C.D. lamp and long-arm control, used in conjunction with the Mk.IIIx sound-locator.

† As, for example, the *Silent Raid* on London, 19th October, 1917. Capt. J. Morris, *The German Air Raids on Great Britain*, p. 187.

‡ *Cf.* Major-General Ashmore, *Air Defence*, pp. 58 and 144.

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this, therefore, demands continued research and experiment with lamps and reflectors directed towards both an increase of range and power of penetration.

The practice known as "jinking," or "beam-dodging," whereby a pilot endeavours to avoid detection or escape from the light by flying on an erratic course, is the most primitive form of tactics employed by raiding aircraft. No trained projector controller should allow himself to lose his target once he has picked it up, provided that the projector is well balanced and the raceway smooth-running.

A stationary or intermittently moving beam is remarkably easy to avoid, as anyone who has been over an illuminated area by night can tell, but by keeping the beam "live" when searching, it is possible to counteract the pilots' efforts to fly round it.

Although it is improbable that an enemy could spare the time for "jinking" when bent on a raid, and it is virtually an impossibility in the case of a formation attacking, it presents the controlling number of the searchlight detachment with almost his only problem and is mentioned here to call attention to the necessity for a "live" beam when searching, and for a well balanced and smooth-traversing projector.

(ii) *Spotters.*

The practice of raiders gaining height outside the lighted area and "gliding" over in almost complete silence, provides a very serious problem, and the detection of such machines, it must be admitted, is at present a matter more of good fortune than good management.

It is unlikely, however, that such tactics could be used effectively in a raid over such a large defended area as that of London; but in the field, where air defence will perforce be limited to small localities, it would seem to offer a very promising chance of evading the defence. Indeed, an R.A.F. report on some operations conducted in August, 1928, suggests that this method "is the only way to ensure that slow night bombers shall get through a defended zone undetected," and this opinion was amply born out by results.* Of eight machines which attempted the raid, only one was picked up before reaching the objective, a glide of some six or seven miles. The same report continued to state that all the machines had height enough to have glided out of the area again in silence, though this was not actually done. And this success was achieved over Regular troops, who had been in constant nightly practice with detachments composed of the same men, for several months!

There is no doubt that a great deal can be done by intelligent and experienced men acting as spotters. The occasional "back-fires" of the throttled-back engines, the accompanying exhaust flashes, and

* No. 7 (Bomber) Squadron, R.A.F., 29.8.28.

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the wind humming in the rigging of the machine, may all be detected by an expert observer. On the occasion under review, officers, N.C.O.s and spotters were in several instances able to detect the hostile aeroplanes from these indications using good binoculars, but to remove the glasses from the eyes meant losing the target, and so no directions could be given to anyone else as to its position. Projector control from the spotter's glass is necessary.

In the past, it has been a regrettable error in many cases to regard the post of spotter as one of low importance. The tendency has been in these days of shifting personnel and reduced establishments* to build up a skeleton of so-called " key-men "—lorry drivers and lamp attendants—from the best available, then to select the listeners from the remaining trained soldiers, and finally to allot the balance of recruits and cooks' mates to detachments as spotters ! And all the time, were it only realized, the spotters are the most important members of the detachment. This is now very generally accepted in theory, but in practice the selection of the men for these duties is still very largely governed by other influences. A bad driver may wreck his machine, a poor lamp attendant let his arc out at a crucial moment during practice, and these are likely to have much more serious results in peace than failing to spot a silent target ; and the writer recalls vividly the case of an excellent spotter who was unfortunately a better batman !

Experience shows, however, that the degree of intelligence required for either of the technical operations referred to above is not nearly so high as that required by a man to become a good A.A. spotter ; and it is possible that a more suitable type may exist in civil life than can be found among any of the Corps trades of which the A.A. Company is composed.

The training of spotters is, unfortunately, difficult, experience being the chief attribute ; and it is all too generally accepted that actual practice by night is the only means of supplying this experience. It is true that, once a certain stage has been reached, by far the best training is for a number of lights in a training lay-out to be deprived of their sound-locators and to have blindfolded projector controllers. But a considerable amount of preliminary training can be undertaken by day, and indoors, once the objects to be aimed at are clearly understood. The preliminary instruction should be divided into two parts, the first of which should teach the man how to pick up his targets, and the second how to bring the beam on to them.

The men should first be taught the use of their glasses. It is generally assumed that any man understands the use of binoculars, but such is not the case. Men are not infrequently found using,

* The A.A. Searchlight Companies of the T.A. are reduced to a strength of sappers equal to only 75% of their war establishment.

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quite contentedly, glasses in which one eye-piece is quite blurred and incapable of being focused, or which suffers from some other defect. It seems incredible, but it has been found necessary to devote a considerable time to instruction in this elementary knowledge, in order to ensure that the men do really use their glasses in focus. This can only be tested on print of some sort, the men being made to read newspaper headlines at thirty yards. With practice, men with good eyesight (and those without should be trained in some other duty) find it easy to read even smaller type. This practice carried out in a miniature range or barrack-room forms an excellent occupation for a rainy day, particularly if the competitive element be introduced, and accustoms the men to see detail through field-glasses.

The next stage is to train the man to appreciate quickly what he sees—a target may just be leaving the field of view as he comes up—and to this end groups of spotters should be taken out to a convenient view-point and, after inspecting for a limited time a conspicuous object such as a milestone, one of the men should be made to lower his glasses and describe in detail what he saw. At first it will be found that he has little to say, but after some practice and instruction as to what is required, he will be able to describe in the minutest detail pebbles, tufts of grass and other inconspicuous objects in the immediate surroundings of the milestone after a glance of only a few seconds' duration. This is very similar to the Boy Scouts' test of observation and, if carried out frequently, soon produces a very noticeable quickening of the brain, which is most essential to good A.A. spotters.

In addition to this, every man should be instructed in the use of his head as a sound-locator, in the principles of "silhouette" spotting, and in the methods of the so-called "Walking-stick School"; and made to practise them whenever an opportunity happens to present itself. The sight of a number of men at work suddenly pointing into the sky on the approach of an aeroplane is undoubtedly comic and the element of foolery is apt to creep in; but if the men can only be made to take this exercise seriously and to school themselves in it continually, it has been found that it becomes a habit with them to come up within a few degrees of the target each time.

The second part of the spotters' instruction is directed towards training his brain to take control of another's at a distance. The instructor moves a disc about on a wall. The spotter, standing some yards away, directs a blindfolded man to follow it with another disc. The speed of movement, slow at first, quicker and irregular at the finish, need not attempt to reproduce actual speeds of target or beam, for the object of the exercise is mind-training and practice in the use of the various tones of voice to ensure close control. But it is advisable to have the discs of proportions relative to the beam

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and target in order that the spotter may accustom himself to the degree of tolerance permissible.

" Spot-chasing," a familiar exercise on cloudy nights, can also be carried out indoors and can be used to provide valuable experience for spotters.

It is regrettable that, up to the present, practically no serious attention has been paid to these forms of training, and even the equipment available for the spotters has been sadly neglected. The recent provision of first-class binoculars has gone far towards improvement in this province, and being given a means of controlling the beam from the spotter's glass,* it is not unreasonable to suggest that efficient working may be achieved, against targets which are to be seen, by spotters alone, unaided by sound-locating apparatus. And this, indeed, may become a necessity if much progress is made in the silencing of aeroplane engines ; or when local shelling or bombing renders the use of the sound-locator impossible. But picked men and serious attention to their training as spotters are necessary before such a result will be achieved.

(iii) *Sound-Locators.*

No reference has so far been made to a subterfuge to which raiding aircraft conventionally resort, namely, " sound-masking," of a high-flying formation by a low-flying noisy decoy. This is generally only effective against the lights immediately beneath the raiders, and the presence of more than one target is nearly always obvious to observers stationed to a flank, and trained N.C.O.s have little difficulty in deciding to leave the " decoy " to the attention of the nearest beam and search for the raiders higher up.

Interference with sound-locators caused by friendly " fighter " patrols appears to be an unavoidable nuisance when working with defending aircraft ; but it need not present an insuperable difficulty to men who have been taught to recognize the noise of a single high-speed engine and to distinguish it from that of a multi-engined bombing machine, and who have been frequently exercised in this work *by day* when they can constantly check their own observations.

It may be assumed that in a fixed defence, such as that of London, the patrol lines will be within closely defined limits and a knowledge of these courses should be of great assistance to the listeners concerned in quickly identifying a friendly patrol. It is, however, a regrettable fact that, during an engagement, before the raider is illuminated, the attempts of the listeners accurately to locate their targets may be frustrated by interference from the approaching friendly " fighters."

Sound-locator instruction should be centralized as far as possible,

* Sights on top of the binoculars do not offer a satisfactory solution, owing to the need for a second person to transmit the observations of the spotter.

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as much greater value can be derived by a class listening on, say, six instruments at one point, under the supervision of an officer and several specially trained N.C.O's. than in single detachments spread round the countryside.

The object of all sound-locator instruction should be to enable the man to visualize what he is hearing and to this end it should be in the form primarily of simple lectures on types of aircraft, their engines and the type of note produced ; and, secondly, of carefully arranged demonstrations by day recurring at frequent intervals.

The actual numbers selected as sound-locator crews should, in addition, be constantly exercised not only in straightforward location of single aircraft, but under conditions of interference such as are envisaged above. Co-operation with the R.A.F. in this class of work has always presented a difficulty, and very little has been attempted so far in the direction of really organized flying for sound-locator training. The more general procedure has been, for many reasons, confined either to listening to a machine detailed to fly for some other purpose on the rare occasions when it passes near enough, catching a few machines as they leave or return to an aerodrome, or on daily flights " over the area " when in camp.

These methods and those of elementary sound instruction do succeed in producing detachments capable of picking up reasonably accurately single machines at normal heights, but experience has proved that the detection of aircraft under interference from other machines is not difficult to men of quite average intelligence, if given opportunities for frequent practice under the same conditions when they can also *see* what they are listening to.

If, however, the question of interference can be dealt with, that of target speed is not so lightly to be dismissed. A recent edition of the *Morning Post** published a photograph of a new design of bombing machine ordered for the R.A.F., which is capable of a speed of 180 m.p.h. A target of this nature flying at ten thousand feet would not become audible to listeners posted on the outer line of lights, until it had proceeded three-quarters of a mile inside the normal sound range. A machine similar to the Schneider Cup winner of last year would first become audible to the same listeners when a mile and a half inside the area, and another thirty-two seconds would take him out of light range in the opposite direction ! This last case is probably looking rather far into the future, as such speeds cannot yet be applied effectively in the case of machines designed for long-range bombing, but it will be appreciated that quickness in locating by sound is the only counter to increase in target speed. With the comparatively slow-moving bombing machines which co-operate with searchlights on most occasions, no necessity arises for extraordinary speed in this work ; and the average good listener

* *Morning Post*, 17th February, 1930.

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of to-day is satisfied to obtain a fix after some nine or ten brackets, lasting anything up to twenty seconds and more. Not only during that time is he unconsciously becoming fatigued, but he is simply wasting time, during which the target might be illuminated, or at any rate, during which the light might be exposed and searching actively for it. Listeners should be trained to make a fix in three brackets at most and exercised at it continually until a determination can be made regularly within the required degree of accuracy. The practice of languidly bracketing is most demoralizing.

Quite apart from the fact that the present sound-locator ring-sight is not graduated beyond 180 feet per second, it must be observed that any error in the determination of the " leading edge " is magnified more in the case of a high speed setting than in that of a low speed ; and thus a high speed machine demands not only more rapid listening, but also more accurate determination of " leading edge." Few men to whom the duty is entrusted know more than eight positions, or ever use more than four ! In the same way as described for the instruction of spotters and the actual listening numbers, these men must be taught and exercised, *when they can also see what they are contending with*, to fix the " leading edge " more accurately and to appreciate when the ring-sight speed setting obviously requires adjusting. An automatic means of determining " leading edge," when perfected, will be an immense advantage.

(iv) *Conclusions.*

From the foregoing considerations of what may to-day be regarded as the chief difficulties in the performance of the primary role of the R.E. in air defence, it will be appreciated that the somewhat sweeping assertion made at the outset is not without sound foundation. If results fail, on occasion, to bear this assertion out, it is because the training of spotters and listeners has not yet reached the standard required in order to obtain the most efficient results ; and for this reason, the questions affecting the selection and training of these members of the searchlight detachment have been referred to at some length.

(B) " . . . *the system of control* . . . "

(i) *General.*

In the consideration of the secondary role of the R.E., a similar conclusion is reached. The part played by searchlight units in air defence control is the collection of intelligence, and the task is broadly defined in the *Manual of Air Defence*,* as follows :—

" . . . to collect and pass on information as to the position, height, course and speed of hostile aircraft."

Before proceeding to review the present position in this province,

* *Manual of Anti-Aircraft Defence*, 1929, Vol. II, Section 2, para. 6.

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it is necessary to have a more detailed interpretation of the actual requirements, and in order to obtain this, some consideration of the uses to which this information is put would appear to be desirable.

In defences where there is adequate depth, timely information as to the height and course of approaching hostile machines may be of assistance to the commander in ordering reinforcements into the air, or in concentrating his "fighters" across the line of attack. It further enables complete records to be kept which furnish useful information as to the courses habitually taken by the enemy, etc., which may be of value in forecasting the probable development of future raids. It also may be used to inform those responsible for the control of the civil population, street lighting, and so on, of the exact moments at which danger commences and ends, thus reducing to the shortest period possible the inconvenience caused both to industry and to the general public.

For all these purposes the accuracy of the information is not required to be of a very high degree; height to within one thousand feet, and position to within one thousand metres being all that is required. In fact, the operation maps in use at fighting area headquarters are not gridded below ten thousand metres!

In the field, however, where, at any rate in the early stages of operations, air defence will be confined to small localities, the depth of the defence is not likely to be sufficiently great to allow time for value to be derived from the information collected for any of the above-mentioned purposes except record.

But, when working in co-operation with artillery, another problem arises. The A.A. gunner requires to know accurately the height of his target and the height-finding instrument which he employs by day is not entirely satisfactory by night.* It thus becomes an additional object of the searchlight reporting system to obtain rapidly a verification of height to within fifty feet. So that, whereas the present searchlight equipment is such that no very marked difference need be drawn between fixed and mobile units in the general consideration of the main problem of detecting, locating and illuminating the target, the factors affecting the collection of intelligence differ very considerably in the two cases and it is necessary to treat each separately.

(ii) *Fixed Azimuth.*

In fixed defences, which can be prepared in time of peace and probably after the lapse of some time at a base of operations overseas, each searchlight can be connected to its section headquarters by telephone. With such a widely dispersed command as is furnished by a searchlight company in action, the provision of these com-

* The U.B.2 height-finder requires a very high scale of illumination to provide the necessary clean "cut" for an accurate observation, and work on anything in the nature of a "woolly" target is liable to considerable error.

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munications for administrative purposes alone will be demanded at the earliest opportunity. Under these circumstances, a system known as fixed azimuth plotting can be used.

This depends for its action on the observation of angles of elevation of two projectors at the instant when the target crosses the "base line" joining their positions on the map. Six searchlights are usually connected to one section headquarters, where the necessary computations are made to determine the height and plan position of the target. When a target passes between two searchlights of different sections, the reports are passed direct to the company headquarters for collation.

In practice, conclusive checks of the results obtained are difficult, owing to the relative inaccuracy of the pilots' own determination of his position in most cases, but a recent detailed analysis of plotting, carried out on the fixed azimuth system in the Isle of Thanet by a T.A. unit of average efficiency in this branch of A.A. work, may be quoted as a fair example. In this case, the various conspicuous towns on the coast-line were made use of as points of entry and exit, and the courses reported by the pilot may, therefore, be accepted as reasonably accurate.

The analysis covers the work of only five nights, but the results do not vary to any extent from night to night. The time-lag remains fairly constant at two minutes; that is to say, the position of the target reached company headquarters two minutes late. Allowing for this, the average error in plan position was approximately two thousand metres; and heights were seldom within three thousand feet of those given by the pilot.

Changes of course inside a ten-thousand metre square were very generally followed correctly subject to a fairly constant error of course angle, fifteen to twenty degrees one way or the other.

Viewed, however, from the rather larger viewpoint of those who make use of the information supplied, these errors diminish into insignificance. The mean only of changes of course inside a ten-thousand metre square is of interest, and this becomes self-apparent as the plot proceeds from one kilometre square to another.

It is not entirely a question of training here, for there are many factors affecting, if not entirely removing, the chances of obtaining accurate results which are beyond the control of the troops. To begin with, the beam itself is dispersed 3 degrees, representing about 500 feet at a height of 10,000 feet, and there is no reason to expect the target to be held centrally in the beam while the readings are taken; in fact, the projector controller's instructions are to keep the target either in the "leading edge" of his beam, or where he can best see it. Then again, a slight eccentricity of the positive carbon, or even an irregular crater, neither of which can always be avoided, must produce a divergence of the beam from the true line of the

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projector ; while the reflector cannot always be said to be mounted dead true and must produce a similar error. Quite apart from these potential sources of error, the pointers are nearly always several degrees wide, even where the degree marks themselves are not!

So that it may be admitted that, with the equipment at present available, the results actually achieved approximate very nearly to the limit of accuracy obtainable by the fixed azimuth method.

It is now very generally realized that every advantage is to be gained by the plotters, or at any rate, the officers in charge, sitting in the open where they can also see what is going on. Under such conditions it is possible to plot a very accurate course by eye alone, and, with but little experience to judge height to within one or two thousand feet. By this means, reports were received in London during the German air raids on Great Britain, within half a minute of the enemy crossing the coast;* and there can be no reason for neglecting to verify the information derived from the lights by the simple expedient of watching the operations in the sky. Yet this is very far from the general practice.

When the target is obscured by clouds, or by day, fixed azimuth plotting can be carried out by reading the required angles from sound-locators ; and in spite of the little-exercised listeners, the results obtained at a trial of this method during the training referred to above, differ hardly at all in accuracy from those obtained by night.

(iii) *Visual.*

In field defences, where such an elaborate system of communications is not possible owing to the time necessary for construction, a different system, known alternatively as "Single Station," or "Visual," plotting, is employed.

In this method, the required information is obtained mechanically from observations in a small scale reproduction of the triangle enclosed by the line of sight from an observer to the target, the horizontal projection of that line, and the height of the plane of flight vertically above the observer. With the apparatus at present in use, this reproduction is made on a horizontal plane which is gridded, plotted and oriented to represent the searchlight lay-out and that portion of the topographical grid which covers it. The line of sight is reproduced by a sighting bar laid on the target, rotating about a point on the horizontal plane which represents the position of the observer on the ground. Each searchlight position on the gridded plane is provided with one or more lines radiating from it. The bearings of these lines are communicated to the searchlights concerned and marked on the bearing scales. When the beam, in following a target, reaches one of these bearings a signal is given, visible to the instrument position. This signal usually consists of a

* Major-General Ashmore, *Air Defence*, p. 93.

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momentary dousing of the beam, and fixes the position of the target somewhere vertically above the given line. The intersection between this line and the vertical plane through the sighting bar, also on target, fixes the plan position of the aeroplane on the grid; and the vertical height of the sighting bar above this point gives the height of the target to the same scale.

When, in 1928, a series of flights was made over a marked course, it was found that, with this system, plan positions were determined to within 1,000 metres and height readings to within 500 or 1,000 feet of those furnished by the pilot. The time-lag is also much less with this system than with the fixed azimuth method, as one complete link in the chain of communication is cut out, and the computation is automatic. On the average, plots were received in company headquarters within half a minute of the observation being made, though frequent delays occurred through the "jamming" of the communications with redundant information.

The degree of accuracy theoretically attainable by this system is still limited by the errors at the projector, for, although the angle of sight could be accurately determined by laying through a telescope with cross-hairs directly on to the target itself, the bearing on which the signal is made has still to be read at the projector. Any error in this will introduce an error into the right angle of the triangle of sight, and a simple calculation serves to show that, observing at a distance of 5,000 yards a target at 10,000 feet, the beam's width itself would account for an error in height of 300 feet. So that, although this method may be expected to yield considerably more accurate results than the fixed azimuth system, and has the additional advantages of saving personnel and equipment, and in reducing time-lag, it cannot be said, in its present form, to offer a possible solution to the gunner's problem of finding height by night.

(iv) *Conclusions.*

Viewing the situation generally, however, it may be stated that such degree of accuracy as is achieved under all conditions with the fixed azimuth system by unpractised troops, is sufficient for the purposes defined for fixed defences, and that the considerably greater accuracy required for co-operation with the R.A. is not to be obtained by these means. The time-lag alone remains an important factor, but this diminishes very considerably with practice, as can be seen from the results obtained by Regular troops when operating this system. On the rare occasions when an effective check has been made, the degree of accuracy was found to be not greater than that quoted above, though the time-lag was materially reduced.

The visual system, on the other hand, provides a means of obtaining heights accurately to within 500 feet, and the correspondingly more accurate determination of position; but it may be asserted that this

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represents the limit of accuracy to be obtained by any system depending upon readings of beam angles taken at the projector.

Long-base height-finding with theodolites, though sometimes used by the R.A., is far from satisfactory, both on account of the difficulty experienced in obtaining simultaneous readings and the time taken in computing.

It is possible that a solution may be found in the automatic collation of courses plotted by two instruments of the visual type working on incorrectly assumed height, and some progress has been made in this method for use by day.

But, while awaiting the advent of some such system, we must admit ourselves unable to assist the gunner to the degree of accuracy required by him; and, admitting the impracticability of achieving this accuracy by means of observations at searchlights, it is, perhaps, not unfair to cease to regard the problem as one for the R.E., and to assume that, when independent means for its solution are forthcoming, these should properly be the responsibility of the R.A. themselves.

Confining ourselves, therefore, for the present, to the purposes defined for fixed defences, it is difficult to see any real advantage in the retention of the former cumbersome system, even where telephonic communication does exist, and it is probable that the visual method will shortly displace it entirely.

To obtain the best results, it is necessary to direct every effort to the elimination of the time-lag, and, in addition, plotters and tellers should be trained not to accept any but very marked and sustained deviations in course reported from section headquarters. The majority of track records produced show an exceedingly tortuous track which was manifestly not pursued, and which would have become automatically straightened out in the course of reporting to sector headquarters.

It results, therefore, in a great saving of labour and reduces the "jamming" of telephone communications if plotters can be trained to anticipate this straightening out. In analysing some records of the type referred to, by removing unrealistic "kinks" and obviously impossible digressions of, perhaps, ten miles and back in one minute on a course at right angles to the main one, and by taking the mean course through the remaining plots, very close approximations to the courses shown by the pilot were arrived at. The plotters must, therefore, be educated to use considerable intelligence in sorting the information received and not, as is all too commonly found, merely act as a recording centre for the accuracies and inaccuracies alike of the several reporting stations.

This theory was well illustrated by the experiment conducted of employing the company serjeant-majors on plotting duties at company headquarters, when the considerably more accurate and

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reasonable tracks produced testified to the advantage of having plotters of superior intelligence who were not afraid to use their initiative.

It should always be impressed on the men employed on this work that the object of plotting stations is not to record the information submitted by the lights, but to provide the best available for the higher command.

(C) " . . . *progressing towards a solution* . . . "

(i) *Economy of Force.*

From what has been said above, it will be seen that, technically, the defence, from the R.E. point of view, has at the present time means both of frustrating the enemy's object of reaching his goal undetected, and also of determining his height and course to within the required degree of accuracy.

But, although the present-day R.E. methods do provide these means, we must not regard them as anything but very primitive and inefficient. There never has been any difficulty in providing armour-plating to withstand the shell of the heaviest gun, but the problem before the naval architect has been to incorporate the heaviest armour possible in a battleship in relation to other factors in design, such as displacement and speed. In other words, his difficulty has been to armour his ship economically. Our searchlight methods of to-day provide a very uneconomical armouring.

To understand this more fully, it is necessary to glance at the organization by means of which these methods are applied.

A.A. searchlights are spaced roughly 3,000 to 3,500 yards apart, and a defence is built up of a series of equilateral triangles having sides of that length. At elevations below 30 degrees, it is found that searchlights illuminate the ground considerably by reflection and for this reason increase in power of the actual light is not likely to affect the spacing to any extent.

It may, therefore, be accepted as a basic fact, that one searchlight cannot effectively be used to cover more than three and a half square miles. That is, the area protected by a company of 24 lights may be taken as roughly 75 to 80 square miles.

Time is of paramount importance to the A.A. gunner and to the R.A.F. fighter, in order to reach the hostile machine with shell or m.g. fire before it reaches its goal. Depth, as in all defence, becomes then of chief importance in illuminated areas in anti-aircraft defences. It is now very generally accepted that the six-light or section lay-out round a small vulnerable point, such as a bridge, is ineffectual in that it does not provide an illuminated target at sufficient range for it to be effectively dealt with from the ground before reaching the

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objective. The diameter of such a defence may be taken as six miles. Allowing with the existing equipment and methods, at least 30 seconds for detection, a hostile machine flying at, say, 100 m.p.h., is in the centre of the defence and unloading his bombs within a minute of being located. Further, even if the defence be located some distance from the vulnerable point with the object of misleading the enemy, competent navigators claim to experience no difficulty, on the majority of nights, in locating their objective and thus avoiding the defence.

The minimum effective illumination may, therefore, be taken to consist of 24 lights. Now each light requires, at present, 10 highly trained N.C.O.s and men for its manipulation. This means that the defence from the air by night of a single point is not to be effected without the assistance of some 350 (including H.Q. and workshop personnel) highly skilled tradesmen.

The Anti-Aircraft Battalion, R.E., with its war establishment approaching 1,400 men, must be the largest unit in the expeditionary force, and yet it is only capable of *assisting* in the defence of four points, while the numbers required for the adequate protection of a large area like London are more readily imagined than enrolled.

It is true that for fixed defences at home, women can be employed for the majority of duties connected with plotting; and blind men were used in the Great War as listeners. Colonel Rawlinson tells us* with what joy they undertook this work which they could do better than any, and with what good results the experiment was attended. But there are difficulties in connection with the employment of such people, and for work in the field only able-bodied men can be used. As can be seen from what has been said earlier, the amount of training required by A.A. searchlight troops to operate the present system successfully is so great as to render any very rapid expansion impossible. So the chief problem seems to resolve itself into one of man-power. How can the number of skilled and highly trained men required be reduced to an economic level?

The target is at present located by listening with the sound-locator to the engine noises of the approaching aircraft. This occupies three men, who must not only have been fully trained and have good hearing, but who must have been in constant practice to achieve a successful result.

It is now an open question whether many experienced listeners on the sound-locator do not obtain their results by fixing the point of "maximum intensity," and not by the correct centring of the so-called "binaural effect," produced by phase difference of the sound waves interrupted by the trumpets of the sound-locator. If this be established, then many of the difficulties in the design of an

* Colonel Rawlinson, *The Defence of London*, pp. 112–114.

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automatic locator disappear and the production of, at any rate, a one-man instrument does not seem to be beyond the bounds of possibility. Given such an instrument, two of the detachment may be dispensed with at once. Further, supply the detachments with automatic lamps and the duties of lamp attendant are so far reduced that they could be combined with those of the engine driver, if the light were placed close to the engine. Being given a form of distant control similar to that in use in coast defence, the long-arm and raceway disappear together with the projector controller, and the projector itself can then be mounted on the lorry, where the engine driver can also attend to the lamp.

The detachment of ten is now reduced to two N.C.O.s and four sappers, and this probably represents the limit of reduction due to labour-saving devices; but it should be quite possible to train the men to such a standard as would admit of running with a detachment of only three, composed as follows:—

1 N.C.O. i/c. spotter, drives by day.
1 sound-locator and spotter, can drive and work lamp.
1 mechanic (lamp and engine) trained as spotter.

These men would take four-hour reliefs in "sky watching" by night and the fatigue experienced as the result of a night's work would be no greater than with the full detachment, while on a night free from raids each man would obtain eight hours in bed.

(ii) *Protection.*

A subject of considerable controversy is that of the protection of A.A. searchlights against bomb splinters. Some consider that the risk of damage is slight and that the raiders will have more important objectives than individual searchlights for their missiles. But history relates occasions when deliberate attacks were made against the lights from the air,* and it is, therefore, probable that protection will be required at the earliest possible moment. With the equipment we have at present an elaborate earthwork is necessary, occupying the detachment of ten some three to four whole days to complete.† Experiments were commenced in 1928, with the object of designing an earthwork protection for the sound-locator and other members of the detachment. It was found that the listening post could be within 30 feet of the projector emplacement without being affected by arc noises. The effect of ground noises or the reflective effect so near the surface of the earth, was, unfortunately, not fully investigated before the experiments terminated. In the experimental

* *Work of the R.E. in the Great War*, Miscellaneous, p. 316.
† *Manual of Field Works, All Arms*, plate 78.

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work the two emplacements were connected by a dog-leg C.T., at the bend of which a post was made for the L.G. and N.C.O. i/c.

This system appeared to provide adequate protection for the whole plant except the engine. In the case of fixed defences, it might reasonably be assumed that some form of stationary engine could be permanently installed in a bomb-proof shelter. But all that can be done for a lorry is to select a spot in a road cutting or quarry, suitable also from the sound-screening point of view, and build up breastworks round the engine and tank. The whole of this work, it was estimated, would occupy the detachment at least seven days under the most favourable conditions. So it would appear axiomatic that, with the existing equipment, it is not worth while starting to " dig in " in any position to be occupied less than a week.

Further experiment in this direction might well be undertaken with a view to deciding upon the most satisfactory dimensions and to producing a type plan for use in fixed defences.

With the detachment of three, much digging would be out of the question, so it will be necessary for the lorry to be armoured against splinters. The sound-locator will, of course, be removed some three hundred yards from the engine to avoid sound interference, and this might possibly be carried on a light trailer with splinter-proof sides, which would also act as a wind-screen to lessen the effect of wind blowing across the face of the trumpets.

(iii) *Mobility.*

The mobility of the plant for field use, at any rate, must be considerable. Cutting out the erection and dismantling times, by having the equipment permanently mounted on the vehicles, will greatly assist this and reduce fatigue in the detachment. On army manœuvres in 1925, searchlights were, on one occasion, dismantled and re-erected three times in 48 hours. This has always seemed one of the most irrational things about the R.E. anti-aircraft equipment. The gunner does not dismount the piece from its carriage and re-assemble it in the gun position !

The lorry must have the highest degree of cross-country performance attainable, combined with a reasonable road speed. In this respect, it should be similar to the R.A. anti-aircraft vehicles, with which it will have to work. The P.E. lorry, though admirable in many ways, possesses no cross-country performance whatever; and the poor starting torque provided by the electric transmission renders it quite helpless in cases of ditching or bogging. For these reasons a geared vehicle seems desirable. The points calling for special consideration in design, such as the provision of a geared generator of sufficient output, extra cooling for stationary running, etc., are simple enough engineering problems and demand no further discussion.

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The substitution of distant control multi-cable for the heavy main cable should result in a considerable saving, both of load and space, and with only three men and their kits to be carried instead of ten, one vehicle should provide ample accommodation without the overloading associated with the present system.

(iv) *Requirements.*

Assuming, then, the detachment of three, the following are required :—

(1) A high standard of training in spotting, which can be obtained on the lines suggested above.

(2) An automatic, or semi-automatic, sound-locator carried on a light armoured trailer.

(3) Distant control from this sound-locator and from the spotter's glass to the projector.

(4) A cross-country type of gear-driven lorry, with electric generator and armoured against bomb splinters ; carrying the projector, with automatic lamp, permanently mounted. Controls of both lamp and engine to be accessible to the same man.

(5) A one-man instrument for height-finding and track-plotting, submitting courses obtained by incorrect assumption of height on the visual system for automatic correction at company headquarters.

Such a system would reduce the numbers employed by one-third, and the searchlight company might then cease to be the mammoth it now is and revert to something less than one of Moses' original hundreds. This should not mean any reduction in peace strengths of A.A. troops, but a vast increase in the protection afforded by the same numbers. In this way, lighting for A.A. defences would be placed on a reasonably economical basis, and the efficient protection of a large area at short notice be no longer the impossibility it appears to-day.

(D) *Conclusion.*

" Where is the man who can fail to see that no city would be proof against surprise, when the ship could be steered over its squares at any time. . . . Iron weights could be hurled to wreck ships at sea, or they could be set on fire by fireballs or bombs ; nor ships alone but houses, fortresses and cities could be destroyed, *with the certainty that the airship could come to no harm* as the missiles could be hurled from a vast height."

Thus wrote Francesco Lana, a member of the Society of Jesus in Rome, when reviewing the possibilities of his aerial ship, designed

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as early as 1670.* It is curious that one whose thoughts were so far in advance of his day should not also have visualized the inevitable parallel development of the defence against air attack. The endeavour has been to show that, so far from the air raider being "certain to come to no harm," under the existing conditions, a successful solution has been found, at any rate, from the R.E. point of view, to the problems of air defence. But the training of searchlight troops is not up to the standard required to apply this solution with safety. It is certain that the present standard can be vastly improved if the possibilities of daylight training are properly appreciated, but the whole method is very uneconomical in man-power and therefore capable of only slow expansion. It is suggested that the real problem to-day is no longer how to detect and illuminate the target, or how to calculate its height and position, but how to do these things economically and with as complete elimination of the personal element as possible. The solution suggested is, it is admitted, Utopian, and is simply an effort to define the objects towards which research in this province should now be directed.

The technical problems connected with the required improvements are not beyond solution, and when solved will largely replace the human element in searchlight work; but *human observation remains that on which success ultimately depends*, and for this reason the greatest attention should be paid to the systematic instruction of *all* members of A.A. units R.E. in the work of spotting or sound-locating.

The work of the A.A. units is little known and still less understood by the Corps as a whole, and it is to be hoped that this article may have the additional effect of dispelling on the one hand, in those minds where it exists, the erroneous impression that air defence is a "black magic," and on the other, of convincing those who regard it as extremely simple, that here, too, the sapper is faced with problems which are not quite so easy as they look.

* Walter Raleigh, *The War in the Air*, p. 30. The italics are my own.

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MECHANIZED CHESS.

By LIEUT. G. V. MICKLAM, R.E.

IT is a far cry from the age of plume, lance, and chain mail, to our age of gas, shell, and aircraft. Nevertheless the mediæval castle the priest and the knight, the courtier the king and the queen, have all breathed their spirit into the miniature battlefield of our ordinary chessboard. Most of us, attracted by the quaint carving of the pieces, by the eccentricity of their moves, and by the excited interest of the players, have at one time or another tried our hand at chess. Whether we have been successful or otherwise, we probably agree that it is a fascinating game—outwardly the slowest, but actually the swiftest, because it is as quick as thought.

As hinted above, the chequered board is in truth a battlefield, and each player the commander of a fighting force, struggling mightily to conquer his opponent's king, while loyally protecting his own to the last. Ethically, then, it is a noble game. In military education it is far more. Hence the old saw that "a good chess-player will make a good General."

Several writers have set out in full the similarities between the art of chess and the art of war. They point out that the immutable Principles of War are identical with the unchanging Principles of Chess. It might not be out of place, however, to bring our game up-to-date in terms of modern armaments and mechanization, and to see how our field of battle fits the sixty-four squares of to-day. Let us first assume the mantle of Alice, and consider our pieces through the military Looking-Glass.

King represents the nation, or the army headquarters, or the ultimate objective, as may be appropriate.

Queen. The air arm. Moves very rapidly, in any direction. Can do much damage by raids, but usually has to return home within a short period, unless well supported (as when ground troops capture an advanced aerodrome).

Castles. The reserve forces. Thrown skilfully into the fight at a late stage, they can entirely save a desperate situation, or improve a good one. A headquarters (king) can quickly interpose the reserves between itself and the enemy in case of temporary emergency ("castles").

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Bishops correspond to the fastest vehicles of an armoured force, armoured cars in particular. They set off early in action, usually to a flank, and along a road. From the flank they are a constant threat to the enemy. The bishop is confined to diagonals in the same way as armoured cars are confined to roads. Moreover no bishop occupies the same sets of diagonals as his partner bishop; correspondingly no armoured car unit should muddle another by using the same sets of roads.

Knights. Other arms of the main body, including artillery in particular. They can attack from behind their own front line. They cannot by themselves checkmate an opponent, but require the support of other forces. The two knights, co-operating closely, can command a wide front within a certain radius.

Pawns. Infantry advanced guards and scouts, in one or two-man tanks. At the beginning of a campaign they move rapidly forward until they bump the enemy (pawn to two squares), whom they pin to a locality, thus securing room for their own main forces to manœuvre in the rear. They never retire, but stick to their posts to the last. Occasionally a small unit will break right through the enemy line, and become as valuable as even the air arm in demoralizing enemy communications (" queens ").

THE CAMPAIGN OF 1936.

Whiteland, under Count Blanc, declared war on Blackland, under General Noir, on March 6th, and thus had the initiative.

The issue lay between contiguous civilized nations, and consequently each possessed accurate maps of the country of the other.

Whiteland.		*Blackland.*
P—K4	The advanced troops of each side were pushed forward by aerobus, until they met and held one another.	P—K4
Kt—KB3	Whiteland had worked out a sound mobilization scheme in peace time, and launched an attack quickly. First objective—to capture the enemy's advanced position.	P—KB3
	Blackland had just been in the throes of a general strike. Owing to a shortsighted financial policy which insisted that all power for W.D. purposes should be taken from the national grid in peace, all arsenals and aircraft establishments	

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Whiteland. *Blackland.*

were a month behind their production programmes. Noir could only reply, therefore, by pushing forward a weak covering force, echeloned to a flank, to protect the forward troops.

Kt x P — Blanc ordered General Knight, commanding the expeditionary force, to continue the planned offensive, regardless of the danger of being cut off.

As had frequently happened in military history, the effect of this premature action was nullified by a vigorous counter-attack by Blackland, and Knight's force, taken off its guard, was annihilated. P x Kt

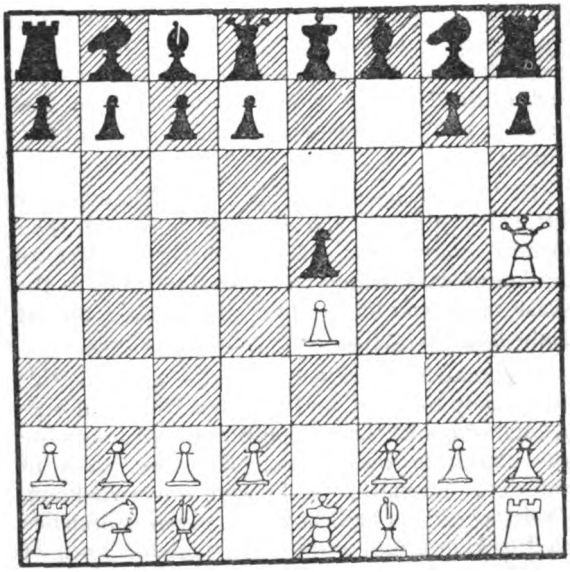

FIG. 1.—Position after fourth move of White.

Under cover of this action, however, Blanc had been able to make the final arrangements for a great air attack, for which everything was now ready (queen's diagonal left clear of obstruction).

Q—R5 (check). Accordingly, on March 12th, twenty-four squadrons of bombers and fighters of the latest type set out against enemy H.Q. This had been located by the incautious use of television on the part of Blackland. An intercepted picture of General Noir in his office showing certain Gothic windows had resulted in the identification of the actual buildings as being a priory ten miles behind the line.

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Whiteland. *Blackland.*

A study of the War of 1914 had impressed Noir with the possibilities of such raids. He pressed a button on his desk, and in a few seconds an area of ten square miles around H.Q. was hidden under a pall of smoke. Under cover of this he K—K2
and his staff made good their escape, and in half an hour had re-opened their offices two miles away.

Q x P (check). The air marshal, however, was not a man to waste time, and with the consent of Blanc he turned west and passed over the area of Blackland's advanced troops, who were weary after their counter-attack, and utterly wiped them out. A detached squadron, aided by a breeze which sprang up and dissipated the smoke, had meanwhile located the enemy's new H.Q., and the air force turned north. Noir's air defence force was not yet ready, and he had to move again at this threat. K—B2

It was useless, however, as although the attacking aircraft had dropped most of their bombs, they were able to direct a fleet of
B—B4 armoured cars, which had just set out from the
(check). base, and Noir found himself attacked on his right flank as well as menaced from above.

Fortunately Blackland's armies were by this P—Q4
time ready to move, and Noir received reinforcements, which he threw rapidly forward to oppose the attack in the centre. They were not in sufficient strength, and were overwhelmed.
B x P Their operations had, however, given confidence
(check). to Blackland, and opened up possible lines of attack for the main armies. It was a pity, therefore, that Noir was himself so near to the battle-front that he was rather apt to be influenced by local operations. K—Kt3

P—KR4 Whiteland followed up their advantage as *Resigns.*
rapidly as possible, on the enemy's unprotected left flank, and Blackland could now see that they were in a hopeless position. A few hours later Noir surrendered, and Blanc dictated the terms of the armistice through phonovision apparatus.

It is, of course, open to question whether the next war would be one of such rapid decision. It seems, however, reasonable to assume that the air arm will be the first to launch a serious attack. Consequently, as far as our chess analogy is concerned, a rapid gambit has been taken as an

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Whiteland. *Blackland.*

example of such strategy. On the other hand, it may be argued that the normal game between players of equal skill is a long drawn-out affair of deep thinking and extensive calculation of time and space.

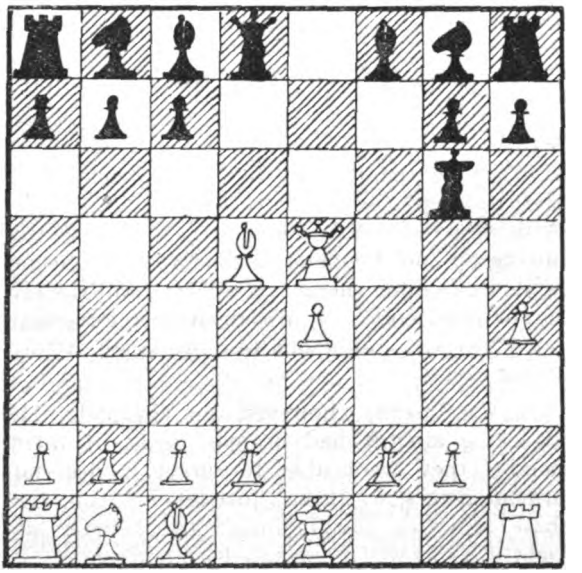

FIG. 2.—Position when Black resigns.

Perhaps, then, chess would point the moral that the next war will be one of still deeper thinking and more extensive calculation.

Take it how we will, our quaint little game reflects the spirit of strategy more truly than any other game, and as such deserves a greater popularity than it now enjoys.

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MEMOIRS.

COLONEL H. W. SMITH-REWSE, C.B., C.V.O., D.L.

HENRY WHISTLER SMITH-REWSE, who died at his residence, St. Loo Mansions, Chelsea, on 24th February, 1930, was born at Glenrock, Sydney, N.S.W., on 8th November, 1850. His father was Thomas Whistler Smith, a well-known Member of the Legislative Council, son of Thomas Smith and Penelope Whistler ; his mother was Sarah Street, daughter of John Street, of Bathurst, N.S.W. Early in 1859, his father came home with his family to take up an important appointment in London, but died the same year. The widow and her family, after living for some years at Tonbridge and other places, settled down at Rochester, where she died in 1892. In 1889, in compliance with a deed by a relative, the name of Rewse was assumed by Royal Licence, in addition to and after that of Smith, from their ancestor, Sir Francis Rewse.

Henry was educated at Tonbridge School. His early love of cricket is recorded in a school report (year not inscribed) which said: " One half of the year he plays at cricket, the other half is occupied with recovery from the attack." Perhaps this was the reason for his transfer to Mr. Fleming, an Army Tutor of the same town. A year afterwards he passed into Woolwich, where he became an under-officer, and whence he passed eleventh of his batch into the Royal Engineers, gaining his commission on 15th December, 1871. His second Christian name was so appropriate to his cheerful disposition that it became a nickname, and he was generally known to his contemporaries as " Whistler."

After the usual Young Officers' Course at the S.M.E., he elected for service in India, and early in 1875 joined the Bengal Sappers and Miners at Roorkee, in time to take part in the Delhi Camp of Exercise of that year.

In 1876, he transferred to the Military Works Department. In 1878, when war with Afghanistan broke out, he accompanied the Khyber Column as Superintendent of Army Signalling, and was present at the capture of the fort at Ali Musjid. He remained with the Peshawar Force till September, 1879, when he returned to Rawalpindi. During the next phase of the campaign, Smith-Rewse again served as Superintendent of Army Signalling, first with the Khyber Force and then with the 2nd Divn., N. Afghanistan Force.

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Colonel Henry Whistler Smith-Rewse, C.B , C.V.O., D.L.

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For his services in this campaign he was mentioned in dispatches, received the medal with clasp, and was awarded a post-dated brevet, being gazetted Bt. Major on 29th December, 1883, after his promotion to captain in that month.

After further service in the M.W.D., he reverted to home service in 1882, and was posted to Chatham in charge of S.M.E. Workshops. In 1883, he was appointed Assistant Instructor in Field Works; but resigned in August, 1884, in the hope of having a greater chance of selection for active service in the Egyptian Campaign. His hopes were not fulfilled, and he remained on general duties at Chatham.

In 1885, however, his chance came; and he was appointed Brigade Major, R.E., of the Anglo-Indian Force, which the British Government had decided to assemble at Suakin after the fall of Khartoum in the previous month, with the purpose of defeating the Dervishes in the Eastern Sudan and protecting the construction of a railway to Berber. Smith-Rewse was present at the action at Hasheen, on 20th March, 1885, was mentioned in dispatches, and received the medal with clasp and the bronze star.

On return to England, in 1885, Smith-Rewse, after a course at the School of Musketry, Hythe, was appointed Instructor of Musketry at Chatham. In 1886, he became once more an Assistant Instructor in Field Works. In 1888, he was appointed Instructor in Tactics and Military Law, and held this appointment for the full five years. He was promoted substantive Major in 1890, and in 1893 proceeded to Gibraltar. In those days there was a great deal of engineer work in progress, mostly under the Military Works Loan; and there were two C.R.E.s as well as the C.E.

In October, 1897, he was brought home to the office of the Inspector General of Fortifications, and in the following month appointed Assistant I.G.F. in the Fortifications Branch, in which he remained until December, 1899, obtaining his promotion to Lieut.-Colonel, in April, 1898. These were halcyon days for the Engineer branch of the War Office and for officers employed on large works, as they were kept on them until completion, and under the Loan system there was no annual lapse of funds.

In December, 1899, he proceeded to Shorncliffe as C.R.E. of that Sub-District, and was there able to supervise some of the work of which estimates had been passed during his service at the War Office. Major J. Stewart, who was Reconstruction Officer during the whole period, writes: "The chief works comprised the reconstruction of the Camp, that is the replacement of the old wooden Crimea huts by permanent barracks, under the Loan. The most interesting work was the reconstruction of the Rifle Ranges at Hythe, which Smith-Rewse did extremely well. Many an evening, after office hours before dinner, he might be found on the corner of Sir John Moore's

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Plain, with a mechanic and a contraption of wires and posts, designing the advancing and receding targets which became a feature of the Hythe Ranges."

In April, 1902, after four years as Lieut.-Colonel, Smith-Rewse was, under the rules then in force, appointed Brevet Colonel.

On 1st October, 1902, he was appointed Assistant Commandant, S.M.E. In October, 1898, the then Commandant, who had been promoted Major-General in the previous April, had been appointed also G.O.C., Thames District. He had continued to occupy the Commandant's House ; and some of the barrack rooms at Brompton had been converted into offices for the District Staff. This dual command and the dual responsibility as to the S.M.E. had been much criticized and inevitably led to perplexities. In December, 1902, Major-General Sir Reginald Hart was appointed to the dual command. This resulted in a most happy combination, a memory of which will be treasured by all who served at Chatham at that period. In April, 1905, Sir Reginald succeeded in divesting himself of the command of the S.M.E. ; and Smith-Rewse was appointed Commandant.

In June, 1905, in order to conform with the recently instituted system in the Infantry, the R.E. Records were transferred from London to Chatham, and a Colonel was appointed O.C., R.E. Depot, as well as O. i/c R.E. Records. This resulted in a very difficult situation—" two kings in Brentford." The offices of the S.M.E. were in barracks under the charge of the O.C. Depot ; and the *personnel* of the S.M.E., both instructors and instructed (including recruits under test in S.M.E. shops), were under the O.C. Depot for discipline. This impossible system was discarded in February, 1907, and the command of the *personnel* of the S.M.E. and the two battalions reverted to the Commandant.

Smith-Rewse's command terminated on the 31st December, 1906. As there were no prospects of further promotion, he elected to retire, and his retirement was gazetted from the following day. During his tenure he and Mrs. Smith-Rewse had taken a lively personal interest in all ranks, and their departure was deeply regretted. An officer who was well acquainted with him at this period, writes : " Colonel Smith-Rewse was very popular with all ranks under him during his time as Commandant, S.M.E. ; he was particularly keen on the Corps maintaining its reputation, especially in sports and games, and was ever ready with help to further this object. Furthermore, he had the great gift of possessing faith in those under him, and allowed them to ' run their own shows ' without undue interference." Sir Reginald Hart, at a farewell dinner to himself on his departure on promotion in November, 1906, said : " During the four years that we have been associated together, and under rather trying circumstances, there has never been the slightest disagreement or unpleasantness. . . . Without his able assistance, encourage-

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ment, friendship and loyalty, I could never have carried out the duties of my two appointments. . . . During the two and a half years I was responsible as Commandant, he was more than my right-hand man; and so loyal to me that he never over-stepped the line or ignored my authority. . . . Were ever two men placed in a more delicate position? It would be very ungenerous of me if I did not publicly acknowledge the debt I am under to Colonel Smith Rewse."

From an early date he showed a flair for organizing "functions," in which he was assisted by his "presence," courtly manners, and *bonhomie*. One of his early contemporaries writes: "Given a free hand and the money, he was sure to produce something to be proud of." During his various tours of service at Chatham it fell to his lot to make the arrangements for many ceremonies in connection with the Corps. In 1888, Lord Wolseley unveiled various Corps memorials in Rochester Cathedral. In 1890, H.R.H. The Prince of Wales unveiled the Gordon Statue at Brompton Barracks. In 1902, Lord Kitchener visited Chatham and dined at the Mess. On 21st October, 1904, H.M. The King inspected the Corps at Chatham and lunched at the R.E. Mess; on this occasion, Smith-Rewse received the C.V.O. In May, 1905, H.R.H. The Duke of Connaught inspected the R.E. at Chatham and lunched at the Mess. On 26th July, 1905, H.M. The King again visited the Headquarters of the Corps to unveil the South African War Memorial Arch. On all these occasions he received the special thanks of those in authority for his arrangements.

During all his periods of service at Chatham, and especially during his tenure as Commandant, S.M.E., he did much to make the Headquarter Mess more comfortable and to maintain its standard and reputation. On his quitting the S.M.E. at the end of 1906, a high official of the Corps wrote: "Your work at the S.M.E. and your influence in moulding the young officers will be most beneficial to the Corps in times to come. You have the satisfaction of knowing that you have held perhaps the most important position in the Corps and have filled it worthily."

Though not a musician himself, Smith-Rewse was a great lover of music and always took the greatest interest in the Corps Band. It is believed that he was the moving spirit in procuring, through the influence of Lord Kitchener, the recognition by the War Office of the two airs known as "Wings" as our regimental march.

He was always keenly interested in amateur theatricals; and was an admirable stage manager, especially in connection with the R.E. Dramatic Society at Chatham, in 1885–1893.

At Gibraltar, as all good sappers should, he hunted with the Royal Calpe Hounds; and in 1897, his Barb pony, "Ruby," gained first prize in a large class at the Horse Show.

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His early liking for cricket has been referred to in connection with his school days. At Woolwich, he played for the R.M.A. *v.* R.M.C., and distinguished himself as a bowler. At Chatham, for the Corps and the S.M.E., he played as opportunity offered up to 1891, and was a regular player at Gibraltar in 1894-7. In 1907, he was elected an agent (hon. member) of the I Zingari, as "a small return for your kindness to the I Z. when we have stopped at Chatham."

He was second to none in his love of the Corps and was always keen to do what he could for its advancement. "An Old Pal" writes: "He was always anxious to mitigate the aloofness that in our early days seemed to separate sappers from the rest of the army." This aloofness, it should be noted, was not the fault of the sappers, but due to the system, continued at least till after the South African War, which kept the sappers in peace work in a sort of water-tight compartment of their own. Smith-Rewse himself always cultivated friendships with officers in other branches of the army.

From early days he was eager to maintain a definite connection between the Corps at Chatham and the Cathedral at Rochester. There had been parade services in 1884 and 1888 for the dedication of Corps Memorials; such services took place again at later dates, but became discontinued. When he was Commandant, S.M.E., he re-started them; and in October, 1908, when Colonel J. A. Ferrier was Commandant, they were definitely recognized by the Dean and Chapter as the "R.E. Memorial Service," and since then have been held annually.

In February, 1908, Smith-Rewse was appointed the first Secretary of the Devon T.F. Association, under the Chairmanship of Earl Fortescue, H.M. Lieutenant of the County. This proved another happy partnership. Both were tremendously keen on their task; both were gifted with tact, and *persona grata* to all with whom they worked. His tenure of the Secretaryship continued through three phases: the constitution of the Territorial Force; its expansion during the Great War; and its re-organization after the Peace. The last, entailing much heart-burning, *e.g.*, in the conversion of yeomanry into artillery, necessitated the exercise of great tact and discretion.

In August, 1917, his name appeared in the *Gazette* in the "List of Mentions" for services rendered in connection with the War; in January, 1918, he was awarded the C.B. (Civil);* and in February, 1922, he was appointed Deputy-Lieutenant of the County.

In November, 1922, he vacated the Secretaryship, after nearly fifteen years in the post. His departure elicited many appreciative references in the papers and personal letters from leading residents in the County. His old chief, Earl Fortescue, after quoting figures

* He had been recommended for the C.B. in 1906 and 1907.

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to show the mass of work that fell upon the shoulders of the Secretary of the Association in dealing with the expansion of the numbers of the Force during the War, the difficulties of providing buildings and equipping the men, the organization of the National Reserves, and the payment of Separation Allowances to wives and dependents, writes: "These figures will give some idea of the quantity and variety of work that passed through the Association's office, though no mention has been made of all applications for commissions, official and private, that came to the Secretary on their way to the Chairman, or of the interviews and odd jobs that fell to the lot of both; but through it all, though harassed by personal anxiety and bereavement, Smith-Rewse was always good-tempered, courteous and efficient. His Chairman, who was likewise Lord Lieutenant of the County, had the satisfaction of obtaining for him the honour of a C.B., a distinction given to very few other Territorial Association Secretaries, and of himself appointing him to be a Deputy-Lieutenant of the County he had served so well."

On leaving Exeter, Smith-Rewse settled down in London. He retained to the last his intense loyalty to the Corps, and was a regular attendant at Corps dinners, receptions, meetings and band concerts. He also maintained his love of cricket: an honorary member of the M.C.C., he was frequently at Lords, and the dullest of first-class matches did not fail to interest. Although, latterly, failing health made him inactive, he was particularly patient, never "groused," and retained his soldierly, upright figure to the last.

His end came quite suddenly from heart-failure, while talking to his wife and his former chief about their happy times in Devon. He was given a semi-military funeral, a gun-carriage being supplied by the R.H.A. The service was held at Christ Church, Chelsea, and the interment took place at Barnes Common.

In 1874, he married Florence Agnata Frances, youngest daughter of Major-General George William Powlett Bingham, C.B., D.L., who, together with one daughter, survives him. His eldest son, in the R.A., died of wounds near Ypres, in November, 1914. His youngest son, formerly in the R.E., who went to France with the Canadian Engineers, was killed in action at Festubert, in September, 1915, while serving as a lieutenant in the Winnipeg Rifles. His second son, a Resident Commissioner in the New Hebrides, met his death as the result of an accident, in February, 1927.

A.T.M.

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COLONEL F. W. BENNET.

FERDINANDO WALLIS BENNET was born on December 13th, 1850, and died in his sleep on October 17th, 1929, after a long illness. He was the son of Richard Gully Bennet, of Tresillian House, Cornwall, and this estate, to which he succeeded on his brother's death, he passed on during his lifetime to his son, Capt. L. W. Bennet, late R.A. In 1896, Bennet married his cousin, Miss E. M. Palmer, daughter of Major-General H. S. Palmer, R.E. Both his two sons served in France, but his second son, Lieut. C. H. Bennet, R.A., died of influenza soon after the Armistice. His two daughters survive him; Mrs. Vivian, wife of Capt. G. P. Vivian, R.N., and Mrs. Ferguson, wife of Major Ferguson, O.B.E., Rajputana Rifles.

After being educated at King's College, Sherborne, Bennet entered the R.M.A., Woolwich, in July, 1868, and was gazetted to the R.E. in January, 1871, Lord Kitchener being of that batch. His meteoric career as a cricketer chronologically calls for notice first. No record exists of his having played at Woolwich, but after joining at Chatham his play rapidly improved until for one season, that of 1874, he was the best bat then in the Corps, if not the best bat ever produced by the Royal Engineers. In that year he made 889 runs for the R.E., with an average of 44·4 per innings, whilst also doing good service as a bowler and in the field. Amongst his biggest scores were 165 not out against the Civil Service, 133 against the R.A., and 127 against the R.M.A., figures which sounded more formidable in those days than at present. And this was when Renny-Tailyour, then known as the best bat in England against bowling not of the very first class, was at his prime. The game which stood out beyond all others in Bennet's memory was when he played under the captaincy of W. G. Grace for Kent and Gloucestershire against All England, making 47 runs. If my recollection is trustworthy, he was for a time at the wickets with Grace, scoring equally rapidly. It is also reported that Bennet was asked to play for England against Australia. After 1874, he seldom played again. He was also a fairly good golfer, playing on one occasion for the R.E. against the R.A.

After leaving the S.M.E. he served at Devonport, at Chatham again, and at Portsmouth, part of the time with a submarine mining company. From 1877 to 1880 he was employed with the telegraph units, part of the time in the south of England, where the Post Office had then handed over the construction and maintenance of their lines to the Royal Engineers.

At the Berlin Congress of 1878, Turkey had agreed to make certain reforms in Asia Minor and to permit the Powers to see by inspection on the spot that these promises were kept—which certainly they

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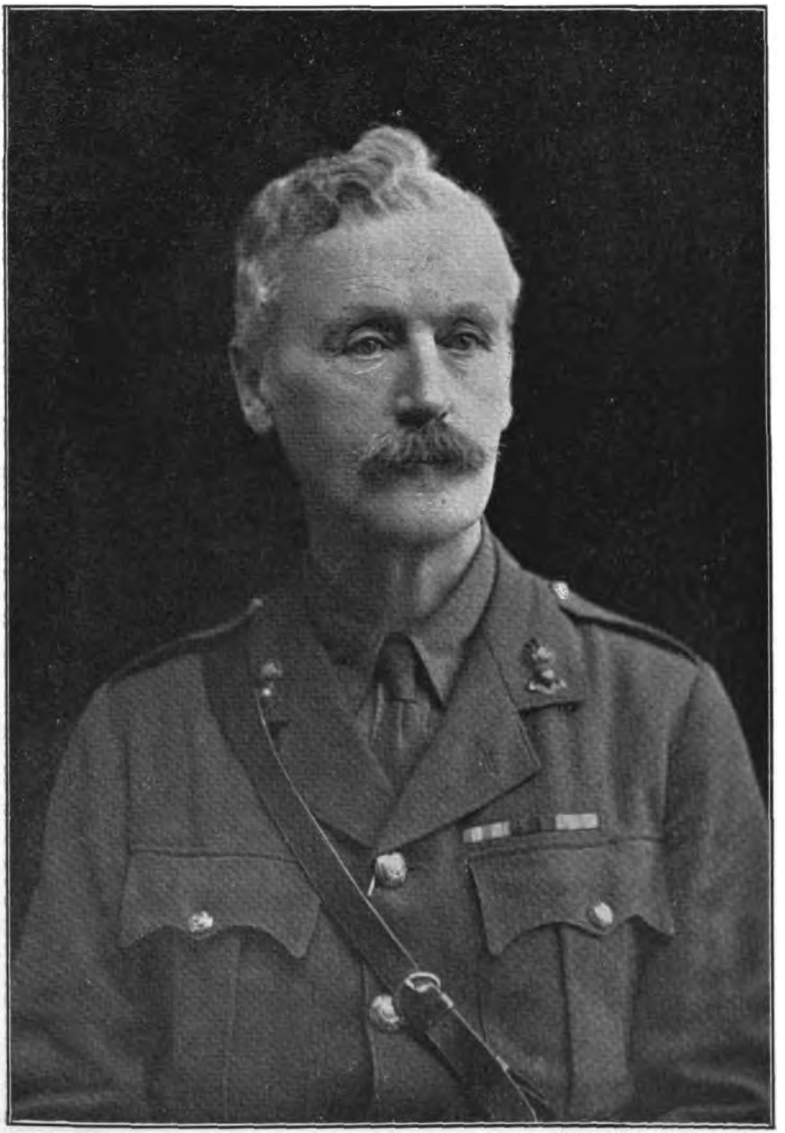

Colonel Ferdinando Wallis Bennet.

Photograph by Hawke, Plymouth.

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were not. Several military Vice-Consuls were, therefore, appointed for service in Asia Minor, having, however, no powers beyond giving advice and attempting to exercise a moral influence over the Turkish rulers. In 1881 and 1882, Bennet was employed on this service under Sir Charles Wilson, the Consul General, a chief whom he revered and whose esteem he won. His companions formed a distinguished group, including Lord Kitchener, Sir Herbert Chermside, and Colonel J. D. H. Stewart, 11th Hussars, the companion of Gordon, who was killed on the Nile in 1884. Bennet was given charge of the Adana district, and made many journeys of inspection, some of them with his chief. It was a dreary task, considering that in many parts the people were bordering on starvation and that little or nothing was being done to relieve their sufferings. He told his friends that the whole place was a seething mass of corruption and that all the officials were lining their pockets as quickly as they could. In most parts the inhabitants were quiet and orderly, being "content to live without hope and without education." In other districts anarchy prevailed and murder and robbery were of daily occurrence. Bennet felt that little good was being done, whilst others held that the work of the Vice-Consuls led to "some beneficial results of a more or less permanent character." Lord Dufferin wrote officially to declare that "a fuller and more exhaustive examination" had probably "never been executed in any part of the East," and directed Sir Charles Wilson to convey his warmest thanks to the Vice-Consuls for their zeal and energy.

It had been determined that for political reasons all the Consuls should be withdrawn in October, 1882; but before that date the outbreak of hostilities with Egypt had taken place, and all these officers were transferred at once to that country. Bennet much enjoyed the liberty of his life in Anatolia, but he must have been glad to quit these dismal scenes. His war service in Egypt on this occasion only lasted a few months, for he was back in England by the end of 1882 with the Egyptian medal and bronze star. He was attached to the Foreign Office for a short while in connection with his work in Asia Minor, and was then stationed at Aldershot for a year.

In 1884, he was again sent to Egypt for service on the Nile expedition, in connection with the Telegraph Department, for which he was mentioned in dispatches, received a brevet majority, and a clasp to his medal. He returned to England in 1885, and was employed until 1888 in the 2nd Division Telegraph Battalion at Falmouth and Edinburgh. From 1888 to 1891, he was second in command of the 1st Division Telegraph Battalion at Aldershot under Colonel "Dicky" Jelf, with G. M. Heath, Curtis, Hunter-Weston, Lyons and H. B. Williams as his subalterns. Then came three years' foreign service at Hong Kong, relieved by a trip with brother officers to Japan, U.S.A., Canada and Alaska, which he enjoyed thoroughly. His

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cousin, Miss Palmer, whom he subsequently married, was serving at Hong Kong at the same time as a nurse, her experiences there including a night on a plague ship with no other woman present and Chinamen dying every hour. On his return to England in 1894, Bennet was first employed at Aldershot, then as a Lieut.-Colonel at Exeter, and subsequently as C.R.E. at Belfast and Woolwich. He left England in 1899 to take part in the Boer War, where he served as A.A.G. on the L.-of-C. and later became Asst. Insp. Gen. of the L.-of-C. For these services he was mentioned in dispatches, made a brevet colonel, and received the Queen's Medal and two clasps. Those were anxious days for all who had the honour of their country at heart, and the earlier phases of the war were graphically described by Bennet as a " proper sickener." With regard to his services both in Egypt and at the Cape it may be said that those who are employed on lines of communication, who do their duty to the complete satisfaction of their seniors, and who are not constantly pulling the ropes in order to get moved forward—why, they are likely to stay where they are. This was essentially true of Bennet. They may, no doubt, console themselves with the thought that they are doing more towards bringing the war to a close than many who succeed in getting into the fighting line. To complete the record of Bennet's military service, it may here be noted that he was recalled in 1915–16 for duty during the Great War for nearly a year as C.R.E. at Plymouth; work which he found very trying, after fourteen years' absence from the Army.

Soon after his return to England from the Cape, that is, in September, 1901, he retired from the Army. He had had, he declared, a very good time in the Service, and had done his best; but he left with joy and gladness to settle down at Fairlea, his house at Northam, N. Devon, which became his centre of interest for the rest of his life, and from which subsequently it was very difficult to get him to stir. It was not far from his favourite Westward Ho ! golf links, where he was for long a familiar figure, winning many medals, and, like a true sportsman, getting much pleasure out of the game whilst, with his declining years, his handicap rose slowly from 3 to 17, so, at all events, he asserted. He probably looked forward to spending the rest of his life in a leisurely way on the golf course, and in his garden pruning his apple trees which were a constant source of interest to him. But after his value came to be recognized in that locality he had little chance of being idle, and once at work again, he soon began to take a keen interest in local affairs, an interest which he maintained until his health broke down a couple of years before his death. At various times he served as chairman of the Bideford County Bench, as Vice-Chairman of the Northam Urban District Council, and Chairman of the district hospital, besides interesting himself in the local Horticultural Society and serving on the Board of Guardians.

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He was especially active in safeguarding local public rights with regard to the removal of gravel from the famous pebble beach at Westward Ho! and thoroughly enjoyed his contests on this point with the Government Departments in London, which he regarded as being both obstructive and obstinate.

In spite of his excellent record of service, Bennet's friends all thought that his abilities warranted a more distinguished career in the Army than that which actually fell to his lot. Probably what told against him most was a certain want of ambition; for he admitted that he had not pushed himself sufficiently, accepting every position as it came, whilst striving to do his duty thoroughly therein. As we have seen, he was not one of those who regard every appointment, whether actually held or only coveted, merely as a rung in the ladder by which to mount to higher places. He had, moreover, a strong sense of humour and a keen eye for the weaknesses of his senior officers; both somewhat dangerous qualities. His dispatches to the Foreign Office seem to have caused amusement at times; as, for instance, when replying to enquiries concerning the administration of the law in Anatolia, he declared, so it was reported, that "there is no justice other than that which can be bought," whilst adding that he had put the dispatch aside for a fortnight in the hope of finding more to say, which he had been unable to do—thus probably giving information as concise and accurate as possible. He was somewhat unconventional in his ways, and cared little for society. For example, when staying in a country house when a dance was taking place for the entertainment of the cricket team of which he was a member, he was found tucked up in bed in perfect peace of mind.

Bennet's was, in fact, a well-marked personality, but one very difficult to sketch in words, though endearing him greatly to his friends and the young officers who served under him. And this must be my excuse for introducing one personal anecdote. He and I belonged to the same batch, and when saying good-bye before all were scattering at the end of our S.M.E. course, he spoke to me somewhat as follows: "Now don't let us have any silly nonsense about writing to each other; no one does keep it up; let us make a bargain never to put pen to paper to each other." On this we shook hands; but this was, in truth, the prelude to a correspondence which lasted with few breaks for over half a century—until he could write no more. Towards the end it was little more than an annual letter, which we both enjoyed, somewhat sadly it is true, as recalling many happy memories of the past. His marked individual characteristics, whilst they may occasionally have surprised those who did not know him well, yet served both to increase the keen feeling of affection which he aroused amongst his friends and to give rise to many pleasant and vivid memories in the minds of a wide circle of acquaintances.

L.D.

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BRIGADIER-GENERAL GILBERT HARWOOD HARRISON, C.B., C.M.G.

GILBERT HARWOOD HARRISON was the elder surviving son of the late Sir Henry Harrison, Bengal Civil Service, and of his wife Fanny Matilda, daughter of Gilbert Abbot à Beckett, the well-known author of the comic histories of England and Rome. Born in June, 1866, he was educated at St. Augustine's College, Ramsgate, and at Beaumont College, Old Windsor, and at the age of 18 received his Commission in the Royal Engineers, having passed out of Woolwich fourth of his batch in December, 1884.

After the usual course at the S.M.E. he was chosen for a further special course of engineering at Armstrong's Works at Elswick, and on its completion was employed at the I.G.F.'s office until February, 1888, when he was appointed Assistant Inspector, Carriage Department, Ordnance Factories, at Woolwich Arsenal. He was at the time a young subaltern with barely three years' service, and the appointment was one that had hitherto been held by senior subalterns or captains only, but he fully justified his selection, and was very well reported upon on the termination of the appointment.

He was promoted Captain in May, 1893, and shortly afterwards was given command of the 2nd Company at Malta, subsequently moving on with it to Cairo on its transfer to Egypt in the following year.

At the end of 1895, Harrison was recalled to England to take up the appointment of Assistant Inspector of Iron Structures at the War Office, and he was serving there at the outbreak of the South African War, when he was sent to South Africa with the 10th (Railway) Company, in October, 1899. He was recalled at the end of the first phase of the war in January, 1901, and shortly afterwards was again ordered to Egypt in command of the 2nd Company.

For his services in South Africa he was mentioned in dispatches (L.G. 10.9.01) and was awarded the Queen's South African Medal with three clasps.

He was promoted Major in September, 1901, and in the following May was appointed Secretary to the R.E. Committee.

On the termination of this appointment in 1907, he proceeded to India on a tour of service, being posted to Allahabad on his arrival there. He was promoted Lieut.-Colonel in 1909, and was transferred to Fort William, Calcutta, as C.R.E. Presidency District. Whilst holding this appointment, he accompanied the G.O.C. on a special tour of inspection in Thibet, visiting all the posts there as far as Gyangtse.

On his return to England in 1912, Harrison was sent to Chatham

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Brigadier-General Gilbert Harwood Harrison, C.B., C.M.G.

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as C.R.E., and was subsequently appointed, in 1914, Chief Engineer, Thames and Medway Defences, on his promotion to Substantive Colonel.

At the outbreak of the Great War, he tried hard to get sent on active service, but it was not until June, 1915, that he could be spared from the important defence works which were being carried out under his supervision. He was then sent overseas, serving as A.D.W. under Major-General Sir Andrew Stuart. He was first quartered at Rouen, and remained there until 1916, when he was made Deputy Director of Works (L. of C. South). Five months later he was given the special appointment of Deputy Director of Works, Independent Air Force, and served in this capacity under Major-General (now Lord) Trenchard until his return to England in March, 1919.

For his services during the War he was mentioned in dispatches and was made a C.M.G. (L.G. 3.6.16). He also received the 1914–15 Star and the British General Service and Victory Medals.

On his return to England he was first of all appointed Deputy Chief Engineer, Eastern Command, and later on, Chief Engineer, with the temporary rank of Brigadier-General. He was holding this appointment when he retired in June, 1923, being granted the honorary rank of Brig.-General on retirement.

Harrison was made a C.B. in 1921, and in addition to the medals for South Africa and the Great War, he received the Coronation Medal of King Edward VII. for acting as one of the ushers in Westminster Abbey during the Coronation Ceremony, and also the Delhi Durbar Medal of King George V.

In 1888, he married Emily Rosina Quint, the adopted daughter of the late Sir Albert à Beckett, and is survived by her; by a son who is a Captain in the Royal Tank Corps; and by two daughters, the younger of whom is married to Capt. R. L. Thompson, R.E., whose father and grandfather are both well-known officers in the Corps.

Quiet and unassuming, Harrison was universally popular. Those who served under him soon realized his kindly nature and his great sense of fairness in his dealings with them, and they looked upon him more as a personal friend than as a commanding officer; whilst those under whom he served fully appreciated his tact, sound common-sense and good judgment.

Shortly before his retirement, his C.-in-C. (the late Lord Horne) sent for him and told him how much he had wished to recommend him for further promotion, but that the precarious state of his health prevented him from doing so. For even at that time he knew that his days were numbered. Unfortunately, the continual strain and hard work of his four years in France had so seriously affected his heart that the doctors told him that, even with the greatest care, he could hope for only a very few more years of life. He refused, how-

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ever, to be a burden to himself and to others by becoming a chronic invalid, and he gamely determined to "carry on" right up to the end. A sincere and ardent Catholic, he fully lived up to his high ideals. Nobody in trouble or want ever appealed to him without receiving ready assistance, not only by the easier method of alms-giving, but also by generous personal service. Many a man who was almost "down and out" has to thank him for permanent work, often obtained only with the greatest difficulty and after the expenditure of a lot of time and trouble on his part.

He was taken seriously ill on his arrival in the Riviera in November last year, but during the whole of his last illness he worried far more over the trouble and inconvenience he was causing to others, than over his own desperate condition.

He died of heart-failure at Bordighera on January 21st, and by his death the Corps loses one who not only tried to associate himself with it in every way, and who was truly proud of being a "Sapper," but also one who, both by the high standard of his work and by the fine example he gave in his private life, successfully upheld its highest traditions.

W.A.H.

COLONEL MALCOLM OF POLTALLOCH.

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PROBABLY the last surviving Sapper officer with both Crimean and Mutiny service was Colonel Edward Donald Malcolm, 16th Laird of Poltalloch, who died there on 20th March, 1930, in his 93rd year. Nearly 76 years have passed since he was commissioned to the Royal Engineers, and they were filled, right up to advanced old age, with public service of varied type. After retirement from the army, he took a keen interest in political work as an upholder of the policy of tariff reform; he constantly visited his family estate in Jamaica; and he was a Deputy-Lieutenant for the County of Argyll.

Born on November 13th, 1837, he was the third son of John Malcolm of Poltalloch by his wife, Isabella Harriett, daughter of the Hon. John Wingfield Stratford, of Addington Place, Kent. Their eldest son, John Wingfield, sat for many years in Parliament, and was created Lord Malcolm of Poltalloch in 1896. On his death in 1902 the peerage became extinct, and he was succeeded in the Poltalloch estate by his brother Edward, the second son, Leonard Neill, having been killed at Inkerman in 1854. Edward served in Turkey in 1855 to the end of the Crimean War, and was also in the Indian Mutiny. He was twice mentioned in dispatches and received the medal with clasp for the relief of Lucknow. Very soon after, he

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was campaigning in the China War. Here he was selected for a special service—that of obtaining good steam coal from Japan (then a jealously closed land) for the British Navy. The mission was successful, and Malcolm received the thanks of the Naval Commander-in-Chief, Sir James Hope. The next call was to Canada, where he built and completed a chain of three forts to strengthen the defences of Quebec on the south side of the St. Lawrence.

Malcolm returned home to become an Instructor at the School of Engineering, Chatham, where he specially studied the new subject of submarine mining defence. From Chatham he was appointed Inspector of Submarine Defences for the War Office. Here his organizing ability was shown, for the service was welded into a whole, able at a few hours' notice to defend all the important harbours of the country at a minimum of expense, since the work was done for the most part by volunteers on the spot.

On retiring from the army, after spending many years as C.R.E. in York, Edinburgh, and elsewhere, he was appointed one of the three Commissioners for re-arranging the boundaries of Scotland, under the Local Government Act of 1889. He was then appointed Engineer Adviser to the Secretary for Scotland for piers and harbours in the Western Highlands and Islands, and held the post from 1890 to 1893. From 1901 he was Honorary Commandant of the Clyde Submarine Mining Volunteers, R.E. He was made a C.B. in 1881, and after retirement from the army was awarded a distinguished service pension. He was a County Councillor for Argyllshire, and was an active magistrate. Like his father, he was both a good farmer and a good landlord, and had the typical interests of a Highland laird. He did much to maintain the breed and extend in many lands the reputation of the West Highland terrier, the oldest sporting dog known. His keenness as an angler was maintained to advanced age, and he was a lover of literature.

Colonel Malcolm married, on July 17th, 1867, Isabella Wyld, daughter of Mr. John Wyld Brown; she died in 1927. Their eldest son is Sir Ian Malcolm, formerly a prominent Unionist M.P., and now British Government Representative on the Suez Canal Board. The second son is Major-General Sir Neill Malcolm, President of the British North Borneo (Chartered) Company. There are three younger sons, all of whom held commissions in the army before and during the Great War, and two daughters, who both married officers of the army.

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MAJOR W. C. HUSSEY, C.V.O.

WILLIAM CLIVE HUSSEY was born 2nd January, 1858, the second son of Mr. Edward Hussey, of Scotney Castle, Lamberhurst, Kent. He was sent to Mr. Lee's preparatory school at Brighton, and afterwards to Eton, where he was in the house of the celebrated Dr. Warre.

At Eton he was a " wet-bob," and he carried his love for rowing to Chatham and found there that his experience was of value to the S.M.E. oarsmen.

Being desirous of passing into the R.M.A., he left Eton in 1873 and attended the classes of Mr. Fowler, at Tunbridge Wells; he passed into " The Shop " in 1875.

At the R.M.A., he was high up in his term, and although he did not pass out head of his batch, he was promoted to be R.U.O. and was awarded the Sword of Honour.

Hussey received his first commission in the Royal Engineers 19th June, 1877.

On leaving Chatham, he was employed at Bermuda, where he acted as Adjutant, and also was A.D.C. to the Governor, General Gallwey. He came home from Bermuda in 1883.

In 1884, he was posted to " A " Troop (Pontoons) at Aldershot. When, in 1885, the Government of the day determined on the Bechuanaland Expedition, organized and commanded by Sir Charles Warren, then a Major in the Corps, Lieut. Hussey was selected for the post of Staff Officer to the C.R.E., Col. A. G. Durnford, and so had a share in operations which, though now almost forgotten, are memorable on three accounts, viz.: (1) Their objects, which were to relieve the Bechuanas from occupation of their lands by Boer squatters, to ascertain that the Transvaal State was respecting its then recently delimited western frontier, and to suppress the republics of Goshen and Stellaland, newly formed outside that line, were completely attained without the discharge of a single shot; (2) the way was opened for the extension of British rule to the Zambesi; (3) Imperial troops were, it is believed, for the first time clothed in brown corduroy, officers and men alike, to avoid the unnecessary casualties among the commissioned ranks experienced in former South African campaigns. The G.O.C. himself rode about with a carbine in a bucket and no sword.

The Imperial troops of the Expedition returned to Great Britain towards the close of 1886, and Hussey resumed duty at Aldershot, being transferred to the Telegraph Battalion at Clifton in 1888. He afterwards acted as A.D.C. to the I.G.F.

In July, 1897, Major Hussey was selected for the post of Assistant

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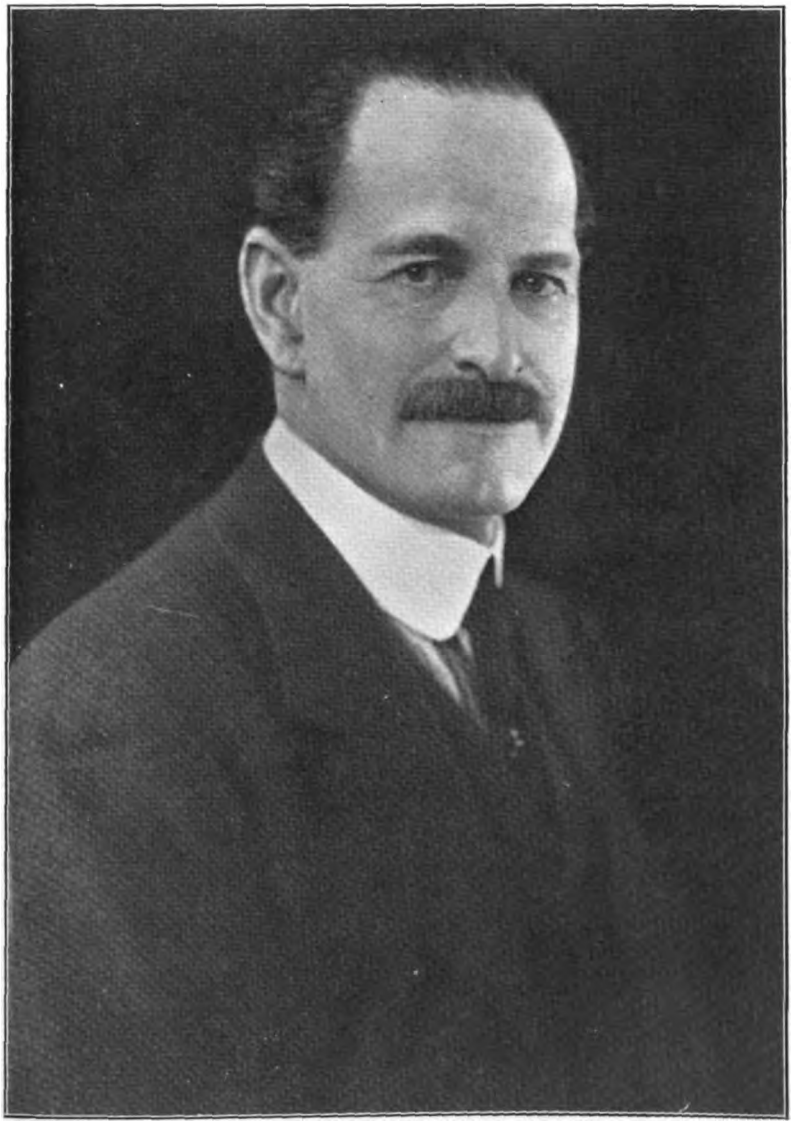

Major William Clive Hussey, C.V.O.

Photograph by Lafayette, London.

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Bailiff of the Royal Parks, under Col. Wheatley, thereby leaving the Corps and becoming an official of the Office of Works ; he succeeded that officer as Bailiff in March, 1902, and held that position till January, 1923, when he had to retire, under Civil Service regulations, on reaching the age of 65. Fond of country pursuits, he speedily mastered the principles of forestry and ornamental gardening, and was able to initiate and supervise much in the way of improvements during his term of office. In particular, he had to reconstruct many miles of road to meet the requirements of modern traffic. He set himself to appreciate the needs both of the country and of the general public in the use of the Royal Parks. The facilities provided for their use were gradually increased, notably in Greenwich Park, by throwing open areas previously enclosed and by the reservation of space for games where this could conveniently be done. As is well known, the floral display was greatly improved. The public functions which required special arrangements to be made by him were numerous, comprising the erection of stands for spectators and the provision of camps for the troops employed on such occasions. As examples may be cited the coronations of King Edward VII. and King George V. ; the funerals of Queen Victoria and King Edward. Such functions necessarily culminated in the Great War, when hospitals, training camps, aerodromes, stores and offices were erected in the Royal Parks. These last duties were carried out with a staff depleted to a nucleus, but it is recorded that, owing to Major Hussey's energy and good temper, no friction arose with the many authorities concerned.

When his time for retirement came, he had earned the good will of all with whom he was associated by his courtesy, cheerfulness and sympathy. A portion of a letter written by Sir Lionel Earle, Permanent Secretary to the Commissioners of Works, may be quoted :—

" I only came into personal contact with him when I was appointed in 1912, but I can testify, from my close association with him during those years up to the period of his retirement, to his untiring activities and efforts to do everything he could to improve the conditions of the Parks for Londoners.

" He was popular with his colleagues, and I think we all missed him when his date for retirement came."

His work was recognized by the award of the C.V.O. in 1923.

Besides his official duties, Hussey served on the Westminster City Council for a few years, and was on the Committee of St. George's Hospital. He was for many years a Churchwarden of St. Mark's, North Audley Street.

Major Hussey was a keen amateur artist, and devoted much of his leave and leisure to landscape painting in water-colours. He excelled in architectural subjects, and particularly in pencil drawings,

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for which his clean and accurate technique was admirably suited. He exhibited frequently at the Royal Amateur Art Society's exhibition, an organization of which he was treasurer for a good many years. On the Selection Committee of the Society his sound critical faculty was of great value. He was a competent horseman and a good shot, and enjoyed games and sport when his leisure permitted them. His tact, his cheery manner and his friendly companionship will always be remembered by those who knew him best.

He married in 1898, Mary Anne, daughter of the Honourable and Very Rev. George Herbert, Dean of Hereford, and is survived by his widow, a son and a daughter.

He died on 20th June, 1929, and was buried at Lamberhurst.

R.W.A.

SIR VINCENT CAILLARD.

(Reproduced by permission from "The Times.")

SIR VINCENT CAILLARD died in Paris, on March 18th, 1930, at the age of 73. He went there for an operation, which was successfully performed, but later contracted pneumonia.

Vincent Henry Pensalver Caillard was the son of his Honour the late Camille Felix Desiré Caillard, County Court Judge, and was born on October 23rd, 1856. On his mother's side he was related to Lord Beaconsfield. He went to Eton in 1869 and was in Mr. Warre Cornish's house. He left in 1872 and passed into Woolwich, where he was Pollock gold medallist, and joined the Royal Engineers in 1875. In April, 1879, he was appointed assistant to the British Commission for the delimitation of the Montenegrin frontier, and in the following October for the Arab Tabia Bridge Commission. He rejoined the Montenegrin Commission in March, 1880. In July of that year he was sent on special political duty to Epirus to report to the Berlin Congress, and in September he was attached on special service to Admiral Sir Beauchamp Seymour during the naval demonstration at Dulcigno. In February, 1882, Caillard was on service for the Intelligence Department, and in August he was attached to the headquarter staff during the Egyptian campaign, for which he received the medal and bronze star and the Medjidieh and Osmanieh Orders. [He retired from the Corps on 26th December, 1883.]

In 1883, he was appointed President of the Ottoman Public Debt Council, and Financial Representative of England, Holland, and Belgium in Constantinople. He resigned in May, 1898, in order

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to join the Board of Vickers, Limited, and received high Turkish decorations. He had been knighted in 1896. For 27 years Sir Vincent rendered valuable service as a Director of Vickers, for which post he was specially fitted by his diplomatic and financial experience. There was no part of that huge concern in which his influence was not felt. He was appointed financial director in 1906, and to his responsibilities in that capacity was added a large share in the control of the Company's foreign operations. Early in 1914, he negotiated for Vickers and Armstrongs the reconstruction of the Turkish fleet and all the Turkish dockyards and arsenals. Work had begun on this contract when the War broke out. It was chiefly due to his initiative and organizing ability that the Company was able to make during the War an enormous contribution to the national output of munitions and other material. He resigned his Directorship in September, 1927.

When Mr. Joseph Chamberlain started his campaign for tariff reform, Sir Vincent Caillard was one of his most energetic supporters, and he served as Chairman and later as President of the Tariff Commission. He wrote much on the subject, and contested Central Bradford in 1906. He also took a leading part in the Federation of British Industries, and was its third president in 1919. In addition to his work with Vickers, he was a Director of the Southern Railway, the Metropolitan Carriage, Wagon, and Finance Company, and other important concerns.

Sir Vincent Caillard had much musical taste, and composed various songs, including a setting to Blake's " Songs of Innocence." His first wife, a sister of the late Sir John Hanham, of Wimborne, was the energetic Commandant of the Red Cross hospital, which she and her husband established at Wingfield House, their home near Trowbridge. She died in 1926, and Sir Vincent married, secondly, Mrs. Zoe Oakley Maund, daughter of Mr. R. E. Dudgeon and widow of Mr. John Oakley Maund. He leaves a son and a daughter by his first marriage.

LIEUT.-COLONEL PETER NORMAN NISSEN, D.S.O.

EARLY in 1916, the problem of providing accommodation in forward areas for the troops in France was becoming very serious. Conditions had changed. The zone subject to shell-fire had widened: many villages had been destroyed and could no longer be relied upon for billeting. Simultaneously, the Expeditionary Force had grown from one to three Armies; a fourth was being formed. The projected advance on the Somme would inevitably entail the concentration of

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great numbers of troops in devastated areas. It was therefore obvious that large quantities of hutting and accessories would be needed in the following autumn and winter months.

At this juncture, news reached the E.-in-C.'s office that a temporary R.E. officer in a Field Company at Ypres had evolved a novel and promising design for a semi-circular hut made principally of corrugated iron. This officer proved to be Nissen, and by a happy coincidence he was appointed in March, 1916, to the command of the 29th Advanced Park Company allocated to G.H.Q. Troops, and then engaged on works in connection with the move of Headquarters from St. Omer to Montreuil. These works were carried out with remarkable efficiency and rapidity under the C.R.E. G.H.Q. troops, and in the course of their execution Captain Nissen came closely into touch with the E.-in-C.'s Staff.

An experimental hut was erected, the details of which naturally needed considerable modification in order to provide for standardization, portability and interchangeability of component parts before the design could be finally approved for manufacture. But Nissen's original ideas were confirmed, and the success of the final design was mainly due to his ingenuity, energy and intimate knowledge of workshop practice. Originally intended to provide weatherproof sleeping accommodation and shelter for men in forward areas, Nissen huts were utilized and adapted for every conceivable purpose. Eventually more than 100,000 of them were manufactured at a cost of probably not less than £6,000,000, and were supplied to British Armies on every front and to the American Forces. They may still be seen standing in many parts of France and in this country.

Nissen and part of his Company for some months were engaged on experimental work connected with accommodation for troops and accessories. The "Nissen" Hospital hut and steel tent; the Canadian-pattern stove, the "Universal" shelter for horses and stores, drying rooms, incinerators, hot-water apparatus for baths, and many other articles required for forward areas were evolved by them, and became well known to all who served in France.

Subsequently Nissen served as C.R.E., G.H.Q. Troops, and in 1918 he became C.R.E., Independent Force, R.A.F., at Nancy.

Nissen came of a Norwegian Canadian family, and was trained as a mining engineer. Before the War he made his name as the inventor of the Nissen mining stamps. In the face of much discouragement and opposition he had succeeded by enterprise and persistence in getting them widely adopted in the gold fields of South Africa.

No man was better qualified by experience and technical ability for the special work entrusted to him. He had genius for design and adaptation combined with a fertile imagination. His personal skill with tools was remarkable, and enabled him to gauge accurately the

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capacity of machinery and labour. It may be mentioned that in 1921 he designed and executed the War Memorial of the Institution of Mining and Metallurgy, of which he had long been a prominent member. Before the War, a statuette of his was exhibited at the Royal Academy.

Cheery and humorous, he was a most attractive personality. He brought into all his enterprises the enthusiasm and optimism of a boy, undeterred by occasional failures, of which in later life he had his share. His premature death in April last at the age of 59 was deplored by a very large circle of friends, amongst them many R.E. officers. His association with the Corps in the Great War was most happy, and contributed a notable share to the solution of many problems related to the well-being and efficiency of the Armies in France. His name, identified with the well-known hut, will be remembered when those of many men more conspicuous in the Service have been forgotten.

NOTE.—The "Nissen" hut, which was the descendant and enriched relation of the "Elephant" and other similar steel shelters adopted for trench warfare, was designed to give sleeping accommodation for 16 men with a floor area of 20 ft. x 16 ft. The roof consisted of curved corrugated iron sheeting, 8 ft. radius on curved steel ribs, lined with matchboarding or a thinner gauge of corrugated iron. Windows and doors were provided at the ends, which, like the floor, were of wood panels.

The total weight was under three tons, so as to allow of transport of a complete hut in a lorry. Each component part could be readily man-handled, and the whole assembled by unskilled labour. In a competition a party of 1 N.C.O. and 8 men of a Field Company, 51st Division, completed a hut from stacked materials in 1 hour 50 minutes.

W.A.L.

CORRECTION TO MEMOIR OF MAJOR-GENERAL SIR S. ROBERT RICE, K.C.M.G., C.B.

THE description of the inception of the Rice blockhouse given on page 348 *R.E. Journal*, June, 1930, is not intended to suggest that blockhouses were not of general use for defensive purposes in South Africa prior to the attacks on the railways by the Boers. Blockhouses had, in fact, been incorporated in the defences of Komati Poort as early as August, 1900, by order of the E.-in-C. (Maj.-Gen. Sir Elliott Wood, K.C.B.), who persistently urged the importance of this form of field defence against an enemy who had no artillery, basing his claims on his war experience at Suakin in 1884–5. These early blockhouses had sandbag walls three feet thick with steel loop-hole plates, of the Suakin type, which were erected in a day. It appears, however, that it was the design of the masonry blockhouse which suggested to Rice's imagination the possibility of an alternative design of almost universal application, constructed of material which was simple to handle and put together, easy to transport, and readily obtainable.

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BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

A HISTORY OF THE BRITISH ARMY.

By the HON. SIR JOHN FORTESCUE, K.C.V.O., LL.D., D.LITT.

(Vol. XIII, with a separate volume of Maps and Plans. Price 40s. net. The set of 13 volumes with Maps and Plans, £16 16s. net.)

The thirteenth and last volume of this monumental work covers the period 1852–1870, and completes the story of the Old Army. The author leaves it to some other hand to write the history of the New Army which grew up after the Cardwell reforms had abolished purchase for officers and instituted short service for soldiers.

It is not often that in a military history we can gain useful light on the political questions of the present day. That the heads of the Army have often been at loggerheads with the politicians is unfortunately a fact, and the author has to refer to it time and again throughout his work. But in this volume we find a whole chapter dealing with a question which is in the forefront of British politics to-day. The author has done useful service in placing it on record. Many of us would wonder what connection there can possibly be between the policy of Free Trade and the Army! A perusal of the opening chapter will show that the adoption of the policy of free exchange in 1846 affected the army in several ways.

It is necessary to recall the fact that as a result of the famine in Ireland in1 845, Sir Robert Peel was induced in the following year to repeal the Corn Laws. "The effect," writes Sir John Fortescue, "on "British agriculture was gradual, but in the end—after the disastrous "season of 1879—crushing. Cobden and his supporters always repudi- "ated the possibility of any such result, but farsighted men predicted "it to be inevitable, and they were right. No doubt the leaders of the "movement acted from the purest motives. They were indeed jealous "of the country gentlemen who had so long ruled England, and they "pined to overthrow them in the name of liberty; but it would be "unjust to trace their action consciously to this source. Among their "followers, however, there was a vast body of self-seeking men, par- "ticularly in the industrial north of England, who desired cheap food, "in order that they might obtain cheap labour and make large profits, "and these formed the majority which imposed Free Trade on the "nation.

"The military significance of Free Trade was threefold:—

"First, it relieved the Army from the duties of the preventive service

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" which had absorbed a great part of its energies at home since 1662.
" This was beneficial to the Army, though little was said about it.

" Second, there was the military danger of leaving the country unable
" to feed itself without importing corn. Of this no account was taken.
" The logical outcome of the policy should have been an increase of the
" Navy in order to secure transport from overseas. The fleet had as
" a matter of fact in the generation after Waterloo been allowed to sink
" to dangerous weakness, and the peril was greater inasmuch as the
" advent of the railways had destroyed the coasting trade, and thus
" diminished the supply of seamen.

" Third, and this, although of the greatest military importance, was
" also ignored by the greedy rank and file who followed Cobden and
" Bright in 1846—the depopulation of the rural districts and the attrac-
" tion of the peasantry into the towns, with its corollaries of physical
" deterioration in the men bred in the towns and the steady fall in the
" supply of country-bred recruits.

" Little heed was paid by the Free Traders to the warnings of sensible
" men, for their leaders had prophesied that the whole world would
" presently follow England's example, and the result would be universal
" free exchange and universal peace! From a sentimental point of
" view, the policy of free exchange in 1846 may seem to deserve commend-
" ation as a generous act of voluntary disarmament, though assuredly
" it was not adopted without the hope of solid gain. The Free Traders
" were not only absurdly sanguine; they were not only sublimely
" ignorant of history and of human nature; but they had utterly mis-
" conceived the nature of war. They imagined it to be a matter of red-
" coats and guns and bayonets, whereas the root lies in the competitive
" instinct of every human heart and human brain.

" In 1850 Cobden, having failed to get the Army reduced, seized the
" opportunity to press for a decrease in the number of officers, nominally
" on the score of expense. But it was pointed out that the pay of a
" lieutenant-colonel after deducting income tax and interest on the
" purchase price of his commission amounted to only £107 per annum!"

It is only fair to record that it was Cobden who initiated the principle that the grant of self-government to a colony should carry with it an obligation to defray its own military and naval expenditure. The proposal was premature, especially on the naval side, but it was reasonable and long afterwards was gradually adopted. And it was the party to which Cobden belonged that first initiated examinations for promotion in the junior ranks of officers in 1850. It was they, however, who strenuously resisted Lord Derby's Militia Bill in 1852—fortunately without success; and it is their successors who have practically abolished cadet corps in the present year of grace.

So much for politics.

Sir John Fortescue gives us a useful sketch of the war with Russia in the Crimea, and does not spare the authorities which launched the British Army into a European war quite unprepared. This is followed by a general account of the Persian War and the Mutiny in India, in which there is much to digest in view of the unsettled state of India at the present time.

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Short accounts follow of the campaign in China in 1859, the Umbeyla Campaign on the frontier in 1863, the Abyssinian Campaign in 1867, and the wars in New Zealand from 1861 to 1868.

In summing up, Sir John Fortescue shows how the British Army was on active service practically continuously from 1852 to 1868 in some part or other of the globe, and he traces the ups and downs of the Army throughout that period. As each crisis occurred the Army establishments were hastily increased, only to be reduced as hurriedly when affairs assumed a more peaceful appearance.

The Army was always short of the required numbers: it was underpaid and overworked. Such a state of affairs could not last for ever, and in 1867, a Conservative Government which came into power for a short time found itself faced with the problem of placing the army on a proper footing which would enable it to deal with emergencies as they arose without dislocating the whole of the machinery. A Royal Commission was appointed and made the following recommendations:

1. Enlistments should be for general service and not for particular regiments. This was accepted.
2. Military training schools for boys should be established akin to the training ships of the Navy. This was rejected on the score of expense—but has been adopted in the present century.
3. "Localization," meaning what is now the territorial system. This has been gradually adopted.
4, 5, 6. Recruits should receive a greater reward on enlistment: the soldier should get a free supply of necessaries: the ration of meat should be increased. The first of these was accepted, and in lieu of the two last the soldier's pay was increased by two pence per diem. It was then one shilling for wages plus one penny for beer money. Not a great increase, but an important concession.
7. Soldiers should receive an additional twopence a day upon re-engaging for a second term of service. One penny only was conceded.
8. The first period of service should be raised from ten to twelve years. This was accepted.

All attempts to solve the question of an army reserve failed for the time being, and it remained for a Liberal Government—with Cardwell as its War Minister—to solve the problem, together with the abolition of purchase, in 1870–71.

The disgraceful condition of the barracks at home and abroad had already received some attention, and the troopship service had been improved.

In his penultimate chapter, Sir John Fortescue has a good deal to say about the Commissariat and Transport services. He has recently written the first volume of the History of the Royal Army Service Corps, which is shortly to be published by the officers of that Corps, and his researches on their behalf have enabled him to include a résumé of his conclusions as to the organization and development of the Corps in his History of the Army. It is to be regretted that he has not found it

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possible to do the same for the R.E., R.A., and other branches, for this History of the Army is to a great extent a history only of the British Infantry.

In his final chapter, the author touches on some of the later developments in the administration of the Army subsequent to 1870, and tells us how the Expeditionary Force Canteen was developed out of the Canteen and Mess Co-operative Society in 1894.

The volume is an extremely interesting one to all old soldiers, and will serve as a guide to the younger, chiefly as to " what not to do " when they rise to high rank. To some politicians it will be hard reading.

The maps and plans are excellent and sufficiently illustrate the campaigns and engagements which are described.

H.B.-W.

HISTORICAL ILLUSTRATIONS TO FIELD SERVICE REGULATIONS, OPERATIONS, 1929.

By MAJOR H. G. EADY, M.C., R.E., *p.s.c.*

(Sefton Praed. 10s. 6d.)

Major Eady has published a new edition of his book, which has already been reviewed in these columns. This edition has a Foreword by Field-Marshal Sir George F. Milne, which in itself is an ample review of the book. He says: " I should have liked to have had this book by me " when I first started on my profession; as an introduction to the " study of *Field Service Regulations* and Military History it could hardly " be bettered. . . . The book should be useful to those who are studying " for examination or the Staff College provided that it is used as an " *apéritif* to further study rather than as a meal in itself."

The new edition, which has had to be much re-arranged and largely re-written on account of the publication of the new *Field Service Regulations*, includes a great deal of new matter; especially illustrations from the Great War. The latter, as the author points out, has been possible owing to the increase in authoritative works on the subject. The new material is admirably incorporated, and adds greatly to the value of the work. The addition of an index of campaigns is an improvement and should prove of value to students of special campaigns. The cross referencing is excellent. Criticism of such a book can merely be in the matters of detail. It is not clear why illustrations of the old principle of " maintenance of the object " have been omitted. In *Field Service Regulations*, it is true, this no longer appears as one of the principles of war, but it remains in that book, promoted as it were to an essential set down before all the seven principles.

The purist on staff duties will lament the use of the " unauthorized " abbreviation A.G. for advanced guard.

The Table of Contents has one mistake as to the page of the Foreword, and the headings in Chapter VI need re-arrangement on the lines of *Field Service Regulations* to avoid protective bodies such as flank guards, outposts, etc., coming under the heading " Advanced Guards."

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Not only as an *apéritif* to the junior officer, but as a reference book or even a " pick-me-up " for the more mature student of war, the book can be confidently recommended to every soldier, and should find a place not only on his bookshelf but close to hand on his study table.

R.P.P.-W.

THE ASSYRIANS AND THEIR NEIGHBOURS.

By REV. W. A. WIGRAM.

(G. Ball & Sons. 15s.)

In *The Assyrians and Their Neighbours*, Mr. Wigram has written a book of interest, not only to those few who may have visited or served in Iraq, but to all who are students of, or like to keep in touch with, middle Eastern affairs. In the first few chapters of the book the author has given a brief historical introduction to his subject, and, as can only be expected in an attempt of this nature, the reader will find various statements which are perhaps insufficiently endorsed by historical evidence.

It must, however, be conceded that Mr. Wigram has succeeded in giving a picture admirably suited to his purpose as a background for the recent history of the Assyrians.

It is perhaps more with the very slender evidence in favour of the descent of the present so-called Assyrians from the historical nation of that name that the reviewer is tempted to quarrel.

The present Assyrian is a typical hillman, small, sturdy, with aquiline features ; and in fact the reverse of Semitic in type. It seems far more probable that they are the descendants of a hill tribe conquered, no doubt, by the Assyrian and possibly transplanted to the plains round Mosul (ancient Nineveh), in accordance with that nation's well-known policy of transference of populations. On the downfall of the Assyrian Empire, such tribes would migrate to the hills once more. Such an event would not be in contradiction of the legends still extant amongst them and would perhaps be more in accordance with their physical characteristics and appearance.

There is little doubt that there is a difficult time in front of this small remnant of a nation and its record in the past few years is such as to call for our sympathy and best wishes for its future as part of the Kingdom of Iraq.

G.B.O.T.

A PRACTICAL NOTE ON TUNNELLING IN SHALE AND LIMESTONE.

By R. O. C. THOMSON, M.C., A.M.I.C.E., Executive Engineer, North Western Railway.

(Railway Board of India Technical Paper No. 274.)

This is a brief pamphlet on tunnelling, with reference primarily to Indian conditions. It justifies its title in being essentially a practical note, and gives many useful hints for carrying out this type of work,

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from fixing the centre line of a tunnel through the various stages of driving the heading, enlarging and completing the lining.

The details of timbering for the successive stages are clearly explained in the notes, together with the diagrams, which are good. The reproductions of the photographs are unfortunately mostly very poor and of little use.

The writer only briefly discusses the relative merits of top and bottom headings. In his notes and diagrams a bottom heading is usually indicated, and he would appear to prefer this method, though, as he points out, it is a question on which engineers hold different opinions. Indeed, the circumstances of each individual case must largely influence the decision as to whether top or bottom heading is to be adopted, and no one method can be conclusively preferred for all cases.

The problem of disposal of the tunnel spoil is one such factor of which no mention is made in these notes. In this connection, the writer's note in Chapter IV on opening up the tunnel face might with advantage have been elaborated. The desirability of completing the portal in good time "to hold up the face of the hill" should be noted; and if this is done, there should be no need to delay the completion of the approach cutting.

The importance of packing well between the lining and the limits of the excavation is duly stressed, and various warnings given against causes of accidents, showing the necessity for vigilant supervision.

This pamphlet should be of great assistance to any officer called upon to carry out or supervise tunnelling work.

J.R.R.

AMERICAN CIVIL ENGINEERS HANDBOOK.

By MERRIMAN.

(Published by Chapman & Hall, Ltd., London. Price 40s.)

The average textbook on any engineering subject usually clothes its meat in a good deal of chat, which so far as the engineer is concerned is considered to be superfluous to his needs.

The engineer is generally a busy man and has not the time or inclination to delve into textbooks to search for what he requires. He wants to be able to put his finger on formulæ or other data at once, without first having to read all about how the said formulæ or data were evolved.

The textbook is excellent for a student, but the trained man who has practical problems to solve requires a pocketbook which contains bare facts and figures which are complete and can be found easily. The pocketbook under review is of this nature and deals with the data required by a civil engineer.

The information given is abundant and should meet all the needs of the profession for which it is intended. The articles are somewhat voluminous and could be condensed to a greater extent and still contain the same amount of information as clearly expressed.

The work is divided into twenty-two sections, the first five being

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given up to an explanation of the elements of the sciences used by the civil engineer in his practice and also include useful mathematical tables, such as Logs., Natural and Logarithmic Trigonometrical Functions, Areas, etc.

The sixth section deals with Survey and Map Making and the seventh with Materials and Strength of Materials.

The remaining fifteen give précis of the method usually adopted to solve various problems to be met by the civil engineer, such as the design and construction of foundations, steel and concrete structures—in fact, cover the whole range of subjects dealt with by that branch of the profession.

The contents of the volume are well displayed in a general table at the beginning of the book.

Each section also has its own more detailed Table of Contents and there is also a good alphabetical Index at the end of the book.

The book is bound in brown leather, lettered in gold and would make quite a pleasing addition to any civil engineer's office bookshelf.

From the Sapper's point of view, it is thought that a pocketbook containing all branches of engineering, such as Kempe's *Engineering Year Book*, which is only slightly larger in size, would be more useful.

B.C.T.F.

INTERMEDIATE MECHANICS—DYNAMICS.

By D. HUMPHREY, B.A., B.SC.

(Longman's Modern Mathematical Series, 10s. 6d.)

In his Preface Mr. Humphrey states that his object is to provide the long-felt want of a textbook embodying Calculus methods to fill the gap between the elementary book and the advanced treatise.

His book is designed for Higher Certificate and University Scholarship aspirants, and one's main impression on looking through it is that there is a vast gulf fixed between the requirements of those students who are reading for mathematical scholarships, and of those whose future is to be engineers.

The book contains much essential bookwork, and many excellent worked out examples, all of which is given in clear, and eminently readable form.

The main criticism from an engineer's point of view is that the conception of Moments of Inertia is not dealt with until the last chapter but one, with the result that the linear and rotational applications of Newton's Second Law of Motion are once again completely divorced; that many students find difficulty over rotational motion is due to this almost invariable practice, and one cannot help feeling that advanced students should not be encouraged to look upon the two forms of motion as being in any way different one from the other.

Then again, in Chapter I one cannot agree with the statement that the equations connecting "velocity," "space," "time" and "*constant* acceleration" are "of fundamental importance, and must be remem-

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bered." Constant acceleration is rare in engineering practice, and the parrot-like repetition of these formulæ that one finds even with the better students is a dangerous and quite unnecessary snare.

The use of these formulæ throughout the book has doubtless saved Mr. Humphrey and his compositor a good deal of work, but it is equally certain that his excellent book has not gained in value by it.

In conclusion, one can say that the book contains a great deal of good stuff for students reading either for the Cambridge Mechanical Sciences Tripos Qualifying examination, or even for the Tripos itself, and that the author, if he has not provided the textbook engineering students are looking for, has at least gone some way towards bridging the gap that unfortunately exists.

R.S.R.K.

(*a*) THE THEORY OF ELECTRICAL ARTIFICIAL LINES AND FILTERS.

By A. C. BARTLETT.

(Published by Messrs. Chapman & Hall. 13s. 6d.)

(*b*) TRANSMISSION NETWORKS AND WAVE FILTERS.

By T. E. SHEA.

(Published by Messrs. Chapman & Hall. 32s.)

In these days of long distance telephone messages from one end of the world to the other, the electrical network over which the telephone current passes is exceedingly complicated, and each portion of it is a cause of leakage and impedance in varying amounts, both of which cause distortion of the current wave form and consequently of the voice. It is, therefore, of the greatest importance to be able to calculate the current and voltage at one end of a network when a certain voltage is impressed on the other, and, luckily, exceedingly neat mathematical methods are available for doing this.

All networks may be considered as made up of a combination of simple sections, and artificial model lines may be constructed to check calculated results.

It will be seen that the subject is mainly of interest to communication engineers. Mr. Bartlett's book is an extremely clear introduction to the subject and should be invaluable to students, while Mr. Shea is a recognized authority.

K.H.T.

SEWAGE AND SEWAGE DISPOSAL.

By A. J. MARTIN.

(Macdonald & Evans. Price 2s. 6d.)

This publication is a reprint of two lectures delivered at the Institution of Mechanical Engineers, under the auspices of the Chadwick Trust.

The author, in his Preface, writes as follows: "While my lectures "do not pretend to deal with all the technicalities of Sewage Disposal, I "have endeavoured to set forth its underlying principles in a clear and "interesting manner. I have also given a résumé of the changing ideals

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" which have inspired the treatment of sewage in the past and a survey " of the great advances which have been made in recent years."

We should like to congratulate Mr. Martin upon the success of this endeavour.

The book is eminently readable and conveys a singularly well-balanced idea of the value of the various processes which have been in vogue during the last hundred years.

To attempt to condense such a vast subject into two short lectures is a noteworthy feat and it would be surprising if there was nothing at which the carping could cavil. The chemists have already done so, but Mr. Martin's self-vindication has been both courteous and complete. There are, however, still a few points to which attention might be drawn, *e.g.*, it is interesting to compare the statement that " Disposal " by dilution is the most effective, the least offensive and the most " satisfactory way of purifying sewage," with the criticisms of the method in the following pages.

Again, the question of sludge disposal, the bugbear of most managers, is accorded a bare ten per cent. of the total book. This might surely have been advantageously elaborated, particularly with regard to digestion. It is noticed in this connection that Mr. Martin (p. 58) states that tanks should be large enough to hold three to four months' sludge. This would appear to be a dangerous generalization, which takes no account of either the *Ph* value of the sludge or the actual practice in the most modern German works.

The existence of an optimum temperature for sludge digestion is completely ignored.

In conclusion, the temptation to quote the following cannot be resisted: " One enthusiastic inventor, gifted with more imagination " than the rest, seriously proposed to supply the United Kingdom with " alcohol made from the London Sewage. . . . London is to be con- " gratulated that none of these proposals have been carried into effect."

The congratulation might reasonably be extended to the whole of the United Kingdom! A.D.C.

COMMERCIAL A.C. MEASUREMENTS.

By G. W. STUBBINGS.

(Chapman & Hall. 320 pp. Price 15s.)

The main feature of this book is the clear manner in which the author deals with the somewhat abstruse subject of the measurement of power and energy in unbalanced 3-phase A.C. circuits.

In the first chapter the elementary principles of A.C. circuits are explained. The author uses " p " for angular velocity instead of " w " and the term " average " is used sometimes, but not always to denote the " mean " value of an A.C. quantity. On p. 29, flux is confused with current. Apart from these minor criticisms, the subject matter is clearly expressed.

Chapter II is devoted to 3-phase circuits. It is thought that the explanations would be clearer if the two voltages in a 4-wire 3-phase circuit were referred to simply as " line " (*not* " phase-to-phase ") and " phase " voltages.

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Unbalanced 3-phase systems are dealt with by the method of positive and negative sequence components, and although this treatment is somewhat difficult to follow, it is well worth studying if a proper understanding of the 3-phase circuit is desired.

There is a slip in the numerical example on pp. 62 to 64.

$\frac{\sqrt{3}}{5} = \cdot 346$, $\phi_0 = 19°6'$ and $\cos \phi_0 = \cdot 945$ (not $\cdot 916$, as shown).

This tends to upset the comparison on p. 64.

In Fig. 37, B_1 is the vector I_b advanced by 60°, and B^2 is the same vector retarded by 60°. Also, the phase of the positive sequence component lags behind the vector O V_c.

Chapter III deals with the measurement of current and voltage and all modern developments are given, including two coil induction ammeters and voltmeters and the thermal and copper-oxide rectifier types.

The improved performance of moving iron instruments due to the use of " Mumetal " is clearly explained.

Both the polar and co-ordinate types of A.C. potentiometer are described.

Chapter IV deals particularly with power measurement, Chapter V with instrument transformers and Chapter VI with the measurement of energy. It would appear that on p. 149, line 24, " one-tenth " should read " one-hundredth."

Chapters VII, VIII and IX are devoted to miscellaneous instruments, including power factor meters, frequency meters and phase sequence indicators and to instruments for measuring " reactive power " and kilo-volt-amperes.

The importance of correct connections when installing 3-phase instruments is very rightly emphasized throughout.

The book concludes with a chapter on test room equipment and some notes on the trigonometry of A.C. theory are given in an appendix.

A few misprints occur besides those specifically mentioned above, but they should be obvious to the reader.

The subject matter is thoroughly up-to-date and the references at the end of each chapter will be found of great interest to students intending to pursue the subject further.

All E. and M. officers will find the book useful, particularly on their special course. W.M.

SURVEY OF INDIA.

GEODETIC REPORT, VOL. III.

From 1st October, 1926, to 30th September, 1927.

(Published by order of Brigadier R. H. THOMAS, D.S.O., Surveyor-General of India.)

Perhaps the most generally interesting event reported for the year under review was the determination of the longitude, by wireless time signals, of Dehra Dun observatory as part of the International Longitude Project. This project was referred to in the report of the previous year, when some accounts of the preliminary preparations were given.

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The objects of this world project were: to determine the precise longitude of some 50 observatories, scattered over the earth's surface, all working in co-operation; to acquire a knowledge of the rate of propagation of wireless signals and of the regularity of the earth's rotation. The latter is being investigated by M. Bigourdan, Director of the Bureau International de l'Heure, from the results obtained at certain selected observatories. We look forward with interest to the conclusions he may arrive at. Less intensive observations are being continued at some of the observatories, including Dehra Dun, in an endeavour to discover possible long period or secular changes of longitude. Secular variations of longitude combined with those of latitude should be of great scientific interest.

For the purpose of this project, special wireless signals were emitted from four stations, namely, Bordeaux, Annapolis, Honolulu and Saigon, during the months of October and November, 1926, when all the co-operating observatories attempted to take observations for time and to receive all possible wireless signals during the period.

It is interesting to note that the new value of the longitude of Dehra, obtained by wireless, is 5 hours 12 minutes 11·794 seconds, while the old value, derived from the Indo–European telegraphic arc, in 1894-96, by Burrard and Lenox-Conyngham, was 5 hours 12 minutes 11·770 seconds; at the same time, it should be mentioned that the value of one of the component arcs Greenwich–Potsdam, as determined in 1903, would apparently increase the old value of the Indian longitude by 0·098 seconds. We may, however, look forward to a promised volume, in which the whole matter will be fully discussed.

A Prismatic Astrolabe, geodetic model, together with two transit instruments, were used for the determination of local time.

Anyone interested in the project should consult this report, where the whole operation is given in much detail.

In answer to an enquiry by Professor Wegener, the astronomical latitudes of Indian Stations at which observations had been made at long intervals were scrutinized to see if there was any evidence of earth movement. The result is that there is no evidence of continental drift, " nor, on the other hand, is there any disproof of the existence of a " drift of the order of 50 feet in a century."

The prismatic astrolabe has been used side by side with the transit instruments for determining local time for longitude purposes and it seems to have done its work well. As an instrument for determining latitude, it is not certain whether it will prove sufficiently precise for such exacting work as the determination of the variation of latitude, but for field purposes it should be very suitable.

A personal equation apparatus was devised for use with the prismatic astrolabe. The ideal apparatus is one in which the real star is reproduced as nearly as possible in the artificial one, so much so that the observer should not be conscious of the difference between them. That the observer should also look through the eye-piece of his own instrument and not make use of a separate instrument, as is generally the case in such apparatus. He should also use the same tappet he employs when actually observing. If possible, matters should be arranged so that he can sandwich-in observations for personal equation between his star

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observations. Most of these ideals seem to have been realized in the device, which is described in full detail. The true coincidence of the star images is recorded on a chronograph, which also records the coincidence as judged by the observer. The instrument is erected in the observatory in such a position that the astrolabe when set for observing can be turned on to the artificial star at will. But for the details of this ingenious apparatus we must refer those interested to the actual report, where full description and drawings are given.

Dr. Hunter has a short notice in which he further considers the most probable height of Mount Everest. The latest conclusion is that 29,050 feet is a fair value for the height, and that we must use geoidal heights and not spheroidal. The present time-honoured height of 29,002 feet is measured above Everest's spheroid placed so as to be tangent to the geoid in the plains south of Nepal. Owing, however, to the doubt which must always surround trigonometrical heights when the reciprocal angle cannot be observed, we understand any departure from the original value for record on maps, etc., is not contemplated. Nevertheless, the investigation of this question is of great interest.

Another point of interest to surveyors who have to work in forest-covered areas is the portable observing tower and lattice mast, designed by Dr. Hunter. The former is 60 feet and the latter 100 feet high. The tower weighs less than a ton and takes eight hours to erect. A "Storm-King" pressure-fed petrol lamp of about 500 c.p. was hoisted to the top of the mast and could be seen at a distance of 20 miles. They were used for the geodetic triangulation of the Burma Coast series.

Space does not admit of a reference to all the subjects dealt with in this report, but we may say it will repay a close study by those engaged in the class of work with which it deals. It is to be regretted that other survey departments of the Empire do not issue reports up to the high standard of the Survey of India.

H.L.C.

SURVEYING: AS PRACTISED BY CIVIL ENGINEERS AND SURVEYORS.

INCLUDING THE SETTING-OUT OF WORKS FOR CONSTRUCTION AND SURVEYS ABROAD, WITH EXAMPLES TAKEN FROM ACTUAL PRACTICE. INTENDED AS A HANDBOOK FOR FIELD AND OFFICE USE, ALSO AS A TEXTBOOK FOR STUDENTS.

By JOHN WHITELAW, Jun.

Eighth edition, thoroughly revised and enlarged by COLONEL SIR GORDON RISLEY HEARN, C.I.E., D.S.O.

(London. Crosby Lockwood & Son. 1929. 16s. net.)

This is a standard work which had already gone through seven editions before the present revision. It contains all the usual problems in surveying which are likely to be met with by the civil engineer in the course of his work, and should, in this respect, prove most useful. There is also a full description of the various instruments and their adjustments. Since the book is already somewhat bulky, we think that the description of certain obsolete methods might well be omitted

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in future editions. For instance, no one would now use Lunar Distance, Lunar Occultations, Moon Culminating Stars or Eclipses of Jupiter's satellites for finding longitude, since the wireless method became available. The former methods have only an historic interest and might well give place to a description of the latest wireless practice, which, so far as we can find, is only incidentally mentioned on page 377 as a possible method ; but is not again referred to.

Then, no mention is made of that comparatively new instrument, the prismatic astrolabe, now so largely used for finding latitude and local time for longitude combined with wireless time signals. This is a serious omission which should be attended to in future.

Again, it is hardly necessary in a book of this kind to include a description, with somewhat full drawings, of the Colby bar base-measuring apparatus, which has long since been displaced by more modern ways of measuring bases, though of considerable historic interest as showing how our grandfathers did their work. The same applies to the space devoted to the old theodolites used for the original geodetic triangulations, which are now only museum specimens.

Nor do we think the editor has done justice to aerial surveying. No mention, as far as we can find, is made of the methods developed so ably by Captain Hotine, R.E., and the Air Survey Committee, which have gone a long way since Jones and Griffiths wrote. The use of air survey for the purpose of examining alternative routes for railways to assist in the final selection of the alignment which has to be surveyed on the ground is not mentioned. For rapidity and cheapness in certain classes of unmapped country this has advantages over the older methods.

While we have pointed out where we consider this book might be improved, we do not wish to imply that it does not contain a great deal of excellent and useful matter. Everything connected with railway survey has been gone into in great detail.

The following headings of chapters indicate the scope of the work: Surveying Chain Only ; Surveying with the Aid of Angular Instruments ; Levelling ; Adjustment of Instruments ; Railway (including Road) Surveys and Setting-Out ; Tacheometry or Stadia Surveying ; Tunnel Alignment and Setting-Out ; Surveys for Water Works ; Hydrographical or Marine Surveying ; Astronomical Observation Used in Surveying ; Explanation of Astronomical Terms ; Surveys Abroad in Jungle, Dense Forest and Unmapped Open Country ; Trigonometrical Surveys. The index is only fairly comprehensive. H.L.C.

BELL'S POCKET GUIDES, ENGLISH COUNTIES, KENT.

By S. E. WINBOLT.

(With Illustrations from Photographs by Winifred Ward. Price 6s. net.)

This is the fourth volume issued in this new series of *County Guides*. The get-up is very attractive, the information is accurate, and the illustrations are delightful. The only drawback is that the book must be selective within the limits of size set, and those who require a complete gazetteer of the county must look elsewhere.

P.H.K.

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MAGAZINES.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1930. TOME I.—NOS. 4 TO 6 INCLUSIVE.)

Les opérations de l'Armée belge, 1914–1918.—*Combats de Hautem-Sainte-Marguerite et de Grimde.* The first three chapters, dealing with the field operations of the Belgian Army in August, 1914, appear successively in the numbers of the *Bulletin* under notice. The position of affairs in the early days of August, 1914, is reviewed; the main body of the Belgian Army had taken up a position on the Gette on August 7th, and had there awaited developments. The 3rd Division, having fallen back from Liege on the seizure of the fortress by the enemy, arrived on this river line on the 8th. The Belgian Cavalry Division, which had moved on the 9th *idem* to a position covering the left flank of the Belgian forces, had on the 12th, with the support of the 4th Mixed Brigade, repulsed the attempts of the German cavalry to cross the river at Haelen. The positions occupied by various formations of the Belgian Army on the evening of the 17th; a Belgian appreciation of the situation based on the information then available; the actual positions occupied by the German First Army at dawn on the 18th, and the intentions of the German High Command, are dealt with in introductory paragraphs.

Chapter I contains a detailed description of the situation of the Belgian 1st Division at dawn on the 18th; the Order of Battle of the Division, and the positions occupied by its brigades during the night of August 17th/18th are also set out in No. 4, which is furnished with sketch maps.

Chapter II contains a record of the events of August 18th immediately preceding the collision of the opposing forces: the latest intelligence relating to the enemy, and the orders issued by the staffs of the 1st Division and its brigades are set out in No. 5. The movements of various Belgian units and the positions occupied by them are described in some detail.

Chapter III deals with the action taken by the Belgian High Command to meet the situation. The intelligence received at the Belgian G.H.Q. was of a character to indicate clearly that the enemy could not be successfully held on the line of the Gette by the Belgian Army, and orders were, in consequence, issued for the latter to retire. The telephonic and other instructions issued in relation to the withdrawal from the Gette position are given in No. 6 of the *Bulletin* in considerable detail.

Emploi des mitrailleuses du bataillon du premier échelon dans l'offensive. The original article appears in No. 4; it is an official commentary explanatory of the doctrine relating to the handling of machine-guns

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promulgated in the Belgian *Règlement de l'infanterie au combat.* An attempt is made in the article to illustrate the method which should be employed in practice to give effect to the general principles laid down in the official manual aforesaid.

Le Siège de la Citadelle d'Anvers en 1832. The original article, which is illustrated by plans, etc., is contributed by Major Delvaux; the first three chapters appear in successive numbers of the *Bulletin* under review.

Chapter I contains the early history of Antwerp; an interesting extract is given therein from the memorandum prepared by Vauban in September, 1702, criticizing the old fortifications. Among other matters dealt with in No. 4 are the Walcheren Expedition (1809); a description of the former Citadel, and its bombardment by the Dutch Fleet in 1830; the defence works constructed by General Chassé in 1831; the intervention of an Anglo-French Fleet (to succour the Belgians) in 1832; and the operations carried out against the Dutch Fleet which attacked Antwerp.

Chapter II sets out the role assigned to the former Citadel of Antwerp, and contains an examination of the essential features of this work. The views existing in the early part of the nineteenth century in relation to problems connected with the attack and defence of fortresses are briefly stated, and a description is also given in No. 5 of the various types of armament in use at that epoch.

Chapter III is devoted to the Sieges of Turin (1706), and Pampeluna (1823); both these centres possessed works the design of which closely resembled that of the Citadel existing in 1832 at Antwerp.

Les aspects militaires de la Révolution de 1830. The first three parts of an article under this title by Capt. Wanty appear successively in the numbers of the *Bulletin* under review. The political and other causes which led to the Revolution of 1830 are not gone into by Capt. Wanty, who confines his attention to the military aspects of the situation arising from this upheaval.

A brief description of the Netherlands Army in 1830, and of the military system in vogue in the kingdom at that period, is given in No. 4. The disturbances which took place in the Belgian capital and in the Provinces during the early days of the outbreak; the ineptitude of the authorities; the action taken by the troops; and the attempts made by the civil population to re-establish order are dealt with in the first part of the article. The formation of a Town Guard—*garde bourgeoise*—in Brussels, and the part which it played, are also touched upon therein.

The events of the period August 28th/September 20th, 1930, are dealt with in No. 5. The character of the Town Guard is examined therein. This body, it is pointed out, was in no way anti-dynastic, but consisted of loyalists who had assumed control of affairs, because the authorities seemed powerless to deal with the disturbances, which had assumed a serious aspect. The Prince of Orange, who was popular in Belgium, had received instructions from the King to restore order in the revolting provinces, and, in consequence, proceeded to Brussels. The various measures adopted to maintain order and the reasons why they failed are discussed in the second part of the article. Serious disturbances occurred in Brussels on September 20th, and the banner of revolt was at once

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raised. A Dutch Army was then already on the march to deal with the insurgents.

The preparations for the attack on Brussels are described in the third part of the article, which also contains a short description of the Dutch Army, and of the plan for the attack on the Belgian capital.

Chronique de l'infanterie. Two parts of an article under this title appear in Nos. 5 and 6 of the *Bulletin:* the French doctrine in relation to the employment of machine-guns in the offensive—based on the *Règlement française de l'infanterie* and the *Instruction provisoire pour les unités de mitrailleuses* (1929)—is dealt with in No. 5, and the British doctrine on the same subject in No. 6.

Avec la garde prussienne sur la Sambre en août, 1914. The original article appears in Nos. 5 and 6 of the *Bulletin:* it is contributed by Lieut.-Col. Van Egroo, who points out that the causes which led to the Germans meeting with a serious check on the Sambre in August, 1914, were of a general and also of a special character. The main cause of the failure of the Germans to obtain a decisive victory in the battle of the frontiers is traced to the defects of the German High Command; its organization was faulty, and it also left important matters relating to leadership to too great an extent in the hands of the Army Commanders, and, in consequence, the armies of the German Right Wing failed to co-operate effectively with one another: in other words, decentralization was overdone. The special causes to which the check is attributed are also discussed by Colonel Van Egroo; he considers that the German Commanders in many cases mishandled their troops, and were guilty of committing serious tactical errors.

The developments on the front of the German Second Army leading up to the contact of the German advanced guards with detachments of the French X Corps in position along the Sambre, south of the line Tamines–Jemeppe, are described in No. 5 of the *Bulletin.* The events of August 21st and 22nd are dealt with in No. 6, which also contains an instructive criticism of the German operations.

W.A.J.O'M.

REVUE MILITAIRE SUISSE.

(1930.—Nos. 1 to 6 inclusive.)

L'infanterie de l'avenir. Articles under this title appear in Nos. 1 and 5 of the *Revue:* the first is contributed by Col. Lecomte and the second one by Gen. Rouquerol. Col. Lecomte's article deals mainly with the views contained in the volume entitled *Infanterieangriff und Strategische Operation* by Col. Sonderegger, recently published by Hubert et Cie, Frauenfeld. The volume in question contains a plea for the re-armament of the Swiss infantry, which, it is contended, could not, as organized at present, force a position defended by well-placed machine-guns. Col. Lecomte does not entirely agree with Col. Sonderegger's views, but considers that the latter's proposals are worth following up not merely as a matter affecting the Swiss Army alone, but as a general proposition relating to the problem of providing the infantry generally

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with an armament of a character which will enable it to play its proper role in modern warfare. Col. Lecomte considers that the organization advocated in the volume referred to would convert infantry into a "heavy arm," and make it too cumbrous for field warfare.

Gen. Rouquerol refers in his article to Col. Lecomte's views and also to Col. Sonderegger's book; he then proceeds to carry out an independent investigation with a view to solving the problem of a suitable organization for the infantry. It is inevitable, the General thinks, that improvements in armament must in the future give a marked advantage to the side which, in the opening phase of a campaign, elects to utilize its land forces in defensive operations; the preliminary offensive movements must take place in the air, and it must be from a "manœuvre par infiltration" that a lightly equipped and highly mobile infantry should seek "des succès de surprise." "Heavy infantry" must necessarily be unsuitable for the type of manœuvre proposed.

Quelques remarques sur l'emploi des sapeurs dans nos manœuvres. The original article is contributed to No. 1 of the *Revue* by Major Pache. He points out that his experience at manœuvres has been that infantry commanders frequently find a difficulty in assigning useful tasks to the Sapper units attached to them; further, it would appear that the Swiss *Service en campagne* practically omits all reference to the Engineer arm. For these reasons, Major Pache puts forward a few useful suggestions on the subject.

La guerre aérienne et notre aviation suisse. The original article is contributed to No. 1 of the *Revue* by Premier-lieutenant E. Naef, who urges that credits should be voted with a view to placing the Swiss air arm in a position to play an effective part in a future war.

Quelques réflexions sur l'aviation de chasse. An anonymous article under this title appears in No. 2 of the *Revue.* It is said that erroneous views in relation to aviation in general and fighting machines are widely held in Switzerland, not only by its citizens, but also in the Army. This is partly due, it is suggested, to articles on the subject appearing in the Swiss Press; the good faith of the authors thereof is not questioned. Consequently, with a view to enlightening its readers on this important matter, the editors of the *Revue* have caused a summary to be prepared of the opinions expressed on the subject of aviation in general and in relation to fighting machines in a recent number of the French *Les Ailes,* and publish the same under the foregoing title.

1914 et l'utilité de notre armée. In Switzerland, as in other countries, there is a group which opposes all measures framed for the purposes of national defence. A member of this group has addressed Col. Feyler on the subject: the former raises a number of questions, and, *inter alia,* asks to be furnished with evidence which shall conclusively show that Swiss territory was not invaded by one or other of the belligerent Powers during the Great War alone because a mobilization of the Swiss Army was carried out for the purpose of guarding the frontier, and that the immunity which Switzerland enjoyed was due to no other cause.

The text of the communication received by Col. Feyler is published in No. 2 of the *Revue.* The Colonel has sent his correspondent a little volume entitled *L'antimilitarisme en Suisse,* which contains copies of

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certain German and French documents, the perusal of which ought to leave no doubt in the mind of any intelligent person as to what would, in all probability, have happened had the Swiss Government neglected to adopt the course it followed by showing that the Swiss Army existed for a specific purpose, and would be utilized for that purpose in the event of the rights of its people being violated. The original article also contains categorical replies to the several questions put to Col. Feyler by his correspondent.

Guerre de chasse. The original article, which appears in Nos. 3 and 4 of the *Revue*, is contributed by Col. de Diesbach, who deals therein with the Swiss problem of home defence. He refers to the changes in the strategical situation which have come into existence since the conclusion of the Great War. The possibility of a future war in which Switzerland may become involved cannot, he says, be ignored. What his country has most to fear is an " attaque brusquée." He explains the difficulty which the Swiss Government would find itself in should it order a timely mobilization of its Army, even if convinced that war was imminent, and that the invasion of Switzerland was definitely projected in the plan of campaign to be put into operation. Col. de Diesbach thinks that the best way to deal with an invader, in the event of an " attaque brusquée," would be to resort to the type of guerilla warfare which he describes in some detail in the original article. He discusses the ethical aspects of his proposals, and also deals with the question of the reprisals which would probably follow should his suggestions be put into practice. Finally, he endeavours to meet the possible criticisms of those who may argue that it is difficult, if not impossible, to prepare for and organize the type of warfare advocated by him. He points out that during the Swiss manœuvres of 1928 and 1929 this very type of warfare was " tested out," and that it " proved in."

La guerre aéro-chimique et la défense anti-aérienne. Three further parts, including the final part, of the article under the foregoing title by M. S. de Stackelberg are contained in Nos. 3, 4 and 6 of the *Revue*—the article was begun in No. 2 for 1929.

In No. 3, M. de Stackelberg deals briefly with the problems of coast and frontier defence, particularly in relation to the advent of aviation as an offensive factor; the evolution of coast defence in the present epoch; and the organization of coast defence in some of the important countries. Under the latter head, the aerial defence arrangements in the U.S.A., France, Italy, Great Britain and Japan are described and compared.

In No. 4, the general principles upon which the arrangements for meeting attacks of hostile aircraft should be based are dealt with; the subject is treated under two headings: aerial defence and anti-aircraft defence. Under the former heading, aerial obstacles and aerial " smoke-curtains " are touched upon; under the latter heading, reference is made to recent developments in anti-aircraft artillery, and the subjects of aerial smokescreens and camouflage are also dealt with. In this part of the article, M. de Stackelberg also discusses the tactical problems of aero-chemical warfare.

The final part of the article is devoted to anti-aircraft fire-discipline;

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acoustical apparatus used for the detection of the approach of aircraft; and the disposition of "warning-posts." The article concludes with a brief review of the arrangements made, or contemplated, in France, England and Italy for the protection of the civil population during hostile air-raids.

W.A.J.O'M.

JOURNAL OF THE ROYAL SOCIETY OF ARTS.

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This number of the *Journal of the R.S.A.* contains the Trueman Wood Lecture by Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.SC., LL.D., F.R.S. The subject of the lecture is the "International Movement of Mineral Products in Peace and War," in which the possibility is discussed of preventing war being resorted to simply by ensuring as a certainty that essential minerals shall be lacking to the combatants: in fact, the "mineral sanction" would be a first stage of the "economic sanctions," under Article XVI of the League's Covenant. The advantage would be that this restriction would not involve the general upset of the world's commerce and finance, but at the same time the recalcitrant nations would realize that, after their present stocks of minerals were exhausted, there would be no replenishment available. No power is naturally self-contained in the mineral sense and no nation could hold sufficient stocks of all minerals required for a serious war.

The lecture would be of use to those reading for Staff College and other exams.

P.H.K.

HEERESTECHNIK.

(*August* 1929 *No. continued.*)—*The Screening by Smoke of Industrial Establishments.* A short article deals with this subject, not generally, but giving an account of a full-scale trial. At the instigation of the representatives of the East Prussian towns and in the presence of ministerial officials, an attempt at screening from air attack took place on the 27th May, 1929, the object chosen for screening being the Water Power Works at Friedland, one of the most essential undertakings to be kept going during war. The smoke-producing apparatus consisted of two adapted fire extinguishers, furnished by the Total Co., Ltd., of Charlottenburg, Berlin. Each of these comprises a container of chlor-sulphuric acid, and a high-pressure cylinder containing either carbon dioxide or nitrogen, under the pressure of which the acid is driven through the ejector and broken up fine by the sprayer. Immediately on issuing from the jet the chlor-sulphuric acid combines with the air to form a thick white mist, the density of which is in proportion to the water content of the atmosphere. Strong sunlight affects the production unfavourably. The complete absence of wind is a disadvantage. With a wind velocity of over 9 metres a second the smoke is carried away too rapidly: the best strength is 2 to 3 metres a second.

The exact covering of the object to be screened, and no more, with a smoke-screen would serve only to betray it to the airman. The object

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aimed at must rather be to cover a much larger area with smoke, so that the airman does not know where in the smoke to drop his bombs. At power works, like those at Friedland, this is the more important, since the airman can already locate them fairly well by the aid of the converging power lines.

Photographs are given of the works before the trial started, immediately after the commencement, and twenty-two minutes later. Aeroplane photographs (not reproduced) also show that the trial was a success, and that the works were screened for thirty minutes. No mention is made of the number of containers used or of the cost of the trial, but the advantages are pointed out of having easily movable containers, and good communications, by road or water, through the establishment to be screened.

Air Records. The Fédération Aéronautique Internationale, which is the only recognized authority for all records in the air, awarded twelve world's records between February and June, 1929. Of these, six went to Germany. This brought the percentages of world's air records gained by the leading countries, out of a total of 82 records acknowledged, to: Germany, 40; U.S.A., 20; France, 16; Great Britain, 9; all remaining countries, 15.

Piercing Artificial Smoke-Screens. The British Admiralty is reported as having utilized a scientific discovery for rendering smoke-screens transparent. In 1919, it was discovered that the ultra-violet and the infra-red rays, not directly accepted by the human eye, possess great power of penetration through mist. The idea of using such invisible rays for secret signalling had already been recognized as of high military value, and some progress made in the appropriate means of reception. The reflection of the infra-red rays after penetrating mist offers further possibilities. The untiring activities of the British Admiralty scientific staff and especially of the eminent physicist, Baird, have brought about a successful reception of these reflected rays. Practically, the proceeding appears to be this: the invisible rays sent out from a ship, suitably equipped, pass through the smoke or mist, but are reflected when they strike a ship concealed by the mist. On the transmitting ship a sensitive cell is acted upon by the reflected rays and brings a buzzer into play. From the strength and from the pitch of the sound, one is able to draw certain conclusions as regards the nature of the concealed object, its shape and size; and this can be done with a remarkable degree of accuracy. It is even said that, by means of a system of lenses, the reflected rays, like Röntgen rays on a barium platinocyanide screen, can be made visible. One would thus be able to recognize the ship's profile.

Such an invention is eminently suitable for war purposes and especially for night work at sea. The enormous distance at which ships fight in daylight would limit its utility; but at night, when ships have screened lights, when there is no moon, when it is cloudy, when there is fog, or when smoke-screens are used, the invention should prove invaluable. It is worthy of study for application to land warfare.

Möller's Shadow Line Pointer. This article describes an instrument for the rapid plotting of intersections of bearings, whether obtained

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optically, acoustically or by wireless direction finding. The D.F. stations of whatever sort are represented by small pillars, each placed in position on the map by means of a central base pin, and containing a small 12-volt glow lamp. The base of each pillar is graduated in degrees and is oriented so that a central line of shadow thrown by the lamp can be directed as ordered.

The instrument is made by the Askania Works Co., Friedenau, Berlin; each pillar being 10 in. high and 5 in. in base diameter and weighing 2 lb. They are delivered in wooden boxes, 11 in. x 6 in. x 6 in.

For permanent direction finding, certain improvements are possible. The graduated bases are replaced by large graduated circles, drawn on the map. The tall columns having the lamp on top, which is reflected through an opening in the base, also disappear, being replaced by small slotted cylinders, while the lamps are now placed underneath the board on which the map is mounted, thus giving a much neater appearance.

(*September* 1929 *No.*)—*The Improvement of Infantry Weapons.* The interesting series of articles just concluded on the influence of the technical development of the rifle on infantry tactics has given rise to much discussion on the improvement of weapon performance, and has called forth two articles in the present number, *Bullet Velocity and Tactics* by H. Gerlich, and *Explosive Bullets of the Smaller Calibres*, by A. Focke. The former gives us the ideas of one who has been recently engaged in practical work and investigations. He agrees entirely with the author of the original article, that the technical development of the rifle, constructively and ballistically, is far from having been completed; and also that it is a waste of fighting power to look upon the rifle merely as a weapon of precision for short-range use. Trials and photographs prove that the new 7-mm. rifle, firing a Halger ·280 H.V. Magnum bullet with a muzzle velocity of 1,186 metres a second, is superior to the larger calibre service rifles, both in precision and in destructive effect.

The second article describes the Russian infantry explosive bullet of 1915, the 2-cm. Germany infantry explosive bullet and the French *Matter* explosive bullet. The two former are flat-headed and fire by means of a cap which sends a flame down a hole to the charge, in the one case compressed picric acid, in the other highly compressed smokeless powder. Compared with these, the *Matter* is a great improvement; having no cap, it is brought almost to a point. It is fired by a percussion fuse, the striker of which is driven down on to a fulminate primer.

A number of photographs show what the 7·9 Mauser carbine bullet can do to the shrapnel helmets of various nations, a picturesque and impartial form of advertisement.

The author pleads for the small-calibre explosive bullet that it is a necessity against tanks, that its effect upon human beings is more humane than numerous small perforations by machine-gun bullets, and, in any case, that war, the nations' *ultima ratio*, is no Easter holiday excursion.

Air Affairs in England. A list of firms exhibiting at the Aircraft Exhibition at Olympia, and the number of types shown by each, is given without comment; then a detailed list of the R.A.F. exhibits,

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with notes. Mention is made of the Vickers' Victoria troop transport biplane, which carried 600 people in 83 flights between Cabul and India; and of Short Brothers' flying-boat, *Singapore*, similar to the one used by Sir Alan Cobham in the round Africa flight, the first all-metal flying-boat made in England, with two Rolls-Royce 800 h.p. engines and maximum speed of 130 m.p.h.

Further evidence of England's interest in the air follows in a description of the great air display at Hendon.

The reporter who is always at pains to point out as *avis au lecteur* the military value of what he sees, was specially taken with the Hawker Hornet, said to reach a height of 3,000 metres in four to five minutes, and to fly at least 200 m.p.h. at heights of three to four miles. Nearly the same achievements are claimed for the Hawker Hart day-bomber.

(*October* 1929 *No.*)—*The Great German Wireless Exhibition*, 1929. It would be more correct to call this a broadcasting exhibition, since it contained this year, in distinction from all foregoing exhibitions, only instruments and equipment directly or indirectly connected with broadcasting. The majority of the visitors will hardly have noticed the omission, but it is a moot point whether other branches of wireless should not be represented in future.

A main centre of attraction was the section "Distant Vision," equipped by the Government Post Office, the firm of Telefunken, the Telehor Company, and the Distant Vision Co., Ltd., the two latter working the Mihaly system and the Baird system respectively. The report of last year's exhibition gave an outline of what is necessary in order to provide vision at a distance by electrical means (*vide R.E. Journal*, September, 1929, p. 526). The question to be answered this year is a more advanced one, viz., How can distant vision find a place in broadcasting? All those who participated use the photo-electric cell at the transmitter, break up the picture with the Nipkow disc and use a glow lamp as source of light at the receiver; except Telefunken, who use Weiller's reflector disc and the Kerr cell.

The necessity of distant vision transmission by means of a normal broadcasting sender, and of its reception by means of an instrument that can be switched on to a normal broadcasting receiver, imposes firm limitations on the goodness of the picture.

At 12·5 pictures a second (and this speed, though adequate, is only half that of a flicker-free film) not more than 1,200 picture elements can be shown at a time. At 1 square millimetre per element the picture would not be larger than 3·5 cm. x 3·5 cm., or 1½ in. each way. That is just large enough to show two human heads clearly enough to be recognizable. Any larger picture would be lacking in detail.

In this respect, what can the development of the near future do to improve things? Unfortunately, there are no immediate essential improvements to be expected, since, to get rid of flickering and to improve the pictures in fineness of detail, frequencies ought to be increased at least six times, and the ordinary broadcasting sender of to-day can neither handle such frequencies, nor does the present distribution of wave-lengths permit of such.

As regards results, the post office broadcast a film on 2,000 metres,

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which was only partially satisfactory, owing to a slight swaying of the pictures, and this in spite of the fact that an impermissible solution of a great difficulty had been adopted, viz., the production of synchronization frequencies by a common generator and their distribution to all receivers. Again sacrificing reality to simplicity, these frequencies were sent out over wires.

The Telehor Company and Distant Vision Co., Ltd., both showed receivers for sale to the public at about £15, a price which will not yet make distant vision popular.

More as a curiosity than otherwise, the post office had installed in communication with each other two telephone call-boxes, in which the speakers could alternately see each other.

Picture telegraphy this year has taken a distinct step backwards. The public seems to have little use for a permanent picture, which takes some time to come through. The uses of picture telegraphy, the sending of photographs for newspaper and police purposes, of meteorological diagrams for aviation, etc., will remain, but for broadcasting to the public it lacks the actuality of the ordinary broadcasting of sound, or of electrical vision. It may amuse, but it is not vivid.

Amongst other items there was this year no outstanding novelty. Much use was made of screened grid valves, especially for H.F. amplification: and it was noticed that most receivers were designed also for electrical gramophone reproduction, both number and quality of "pick-ups" having greatly increased.

Air-Compressors for Army Purposes, by Major Kubitza. The first half of an article deals with this subject under the sub-heads, "Increasing Motorization of the Army: Pneumatic Tools as Necessary and Effective Complement of Engineer Equipment," "Comparison Between Compressors Used for Civil and Military Purposes," "Consequences Derived from the Foregoing." The author points out that, the engineers being the chief bearers of the technical war work in the army, it is with them, before all, that a lack of proportion, between the number and extent of works to be carried out and their existing modest physical working strength, must be made good by the machine. He enumerates many of the engineer's tasks in war, rules out the use of steam and water power, as things to be utilized naturally where found but otherwise having no place in the engineer's war equipment, and reduces the sources of driving power of all the necessary tools to three: (1) the explosion engine, (2) electricity, (3) compressed air.

Of the latter he says: "Pneumatic drive possesses, compared with the explosion engine and electricity, special advantages for military purposes." During the war, mighty rivals to compressed air arose in purely mechanical and in electrical drives, which successfully established themselves in certain fields of activity, a fact chiefly explained by the peculiarities of position warfare. Since the war, however, a movement in the other direction has set in, and compressed air drive, owing to its great advantages, is again taking the first place, and is even prevailing where the circumstances are not unfavourable to purely electrical drive.

Specially suitable for pneumatic working among engineers' tools

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are rams, borers (for all materials), and tools for earthwork. The necessary compressed air is furnished by compressors for which explosion engines are used, or, where transport difficulties are great, electric motors.—(*To be continued.*)

A Short Historical Retrospect of the 75-mm. Gun tells the story of how the French managed to outwit the Germans in the production of this gun. Both France and Germany were experimenting at the time to get an improved field gun, and in both countries there were opponents of barrel recoil. These opponents in Germany gained the upper hand, when bad reports, confirming their ideas, came also from France. Meanwhile the barrel recoil quick-firer was approved in France, the money for it was voted secretly, and the artillery had been armed with it before the Germans discovered that they were on the wrong track.

The writer of the note has nothing but praise for the action of the French, and consoles himself by pointing to the complete surprise caused by the German 30·5 and 42-cm. howitzers in 1914.

Air Affairs in England contains a full account of the Schneider Trophy race and England's great success. It concludes with a complete list of the types of the privately owned aeroplanes, 115 out of 169 of which are Moths. In the remaining 54 there are 2 Klemms and 1 Junkers F13, so that Germany has managed to get a place in what is overwhelmingly British, both as regards machines and engines.

(*November* 1929 *No.*)—*The Pedersen Automatic Rifle*, with 11 photographs and diagrams of velocity, time of flight, trajectory and energy of its 7-mm. bullet compared with the 7·92 Mauser bullet. This is a translation of a pamphlet by Vickers–Armstrong, submitted by the Company to *Heerestechnik* as a contribution to the subject of the increase of effectiveness of infantry weapons, interest in which was aroused by H. Schmidt's series of articles on the effect on tactics of the development of the rifle.

The Pedersen automatic rifle is particularly neat and pleasing in appearance, weighs 8·8 lb., and fires at least 50 aimed rounds a minute in the hands of a trained soldier. The actual firing is not automatic, a point of great importance, both as guarding against excessive expenditure of ammunition, and on psychological grounds as conducive to aimed fire.

Field Fortification, depicted by examples from the history of war, by K. Linnebach, for the Ministry of Defence; with 44 sketches, published by E. S. Mittler & Son, Berlin, 1930, price, marks 7.50.

Out of twelve historical examples extending from 1701 to the Great War, and eminently suitable to his purpose, the author deduces the correct or incorrect use of field fortification as a means of attaining operative and tactical ends. On account of the constantly changing forms of field fortification (of which the Great War furnishes many instructive examples) the author in general omits details of technical execution, except where they are necessary for the understanding of a particular case. In the introduction he says: "Like permanent fortification, field fortification is also a sphinx. Whoever puts himself in her power, without having solved her riddle, she destroys." That the riddle had not been solved at the beginning of the Great War by

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many German leaders, everybody knows. They could only make up their minds to field fortification with difficulty, even when it was necessary. They could only make up their minds with greater difficulty to the abandonment of fortifications, even when the latter had ceased to have any purpose. Before the War, one had not troubled about the solution of the riddle owing to underestimating its value: hence unnecessary and bloody sacrifices. "Field fortification must strengthen the power to attack, not weaken it. Its supreme object is attack." The author has been particularly successful in proving the truth of this extract from the present manual, from the wealth of example in the history of war. The study of this book will make easier the mastery of field fortification, the solution of the sphinx's riddle.

Air-Compressors for Military Purposes (*concluded*). As contrasted with the civil requirements of an air-compressor, viz., low cost of production, high performance, long life (so that as little of the prime cost as possible has to be written off each year), economical running, supervision and maintenance, there is a long list of military requirements: (1) mobility, (2) high output, combined with low weight and small space occupied, (3) raw material for manufacture and fuel to be safeguarded in war time, (4) low petrol consumption, (5) ability to stand rough treatment from man and weather, (6) to be applicable to as many different purposes as possible, (7) requiring little attention, since really well-trained personnel will seldom be available, (8) repairs to be executable without workshops, as these can only be found farther from the front, (9) engine parts to be easily accessible, so that repairs can be carried out on the spot with standard spare parts kept in readiness.

Although the military and civil requirements thus differ considerably, much of the difference is only in degree of importance. Also the same point may be desirable but for different reasons, *e.g.*, economy in running, of obvious importance to the civilian financially, is to the soldier important because of the urgent necessity of keeping as low as possible the amount of transport and the amount of supplies.

The military uses of pneumatic tools are: boring and breaking stone, ramming concrete, boring and sawing wood, drilling, riveting, cleaning and painting iron, excavating and ramming earth. They are required for making dugouts, for mining, for making communication trenches, for pile-driving, for quarrying, for road repair, for hutting and water supply. They must be capable of being carried by mule transport; and they must be issued in peace time so that the engineers are thoroughly accustomed to using them.

A Small English Dirigible gives a short account of AD1, built by the Airship Development Co., as an experiment for social purposes. She carries one-third of a ton besides the crew, has a mean speed of 45 m.p.h., and is in fact an old friend, the Blimp. The makers recommend the type as suitable for private persons, picnics (seats for four) and advertising purposes, for which there are two surfaces, 76 ft. x 24 ft. The engine is an A.B.C. Hornet and can drive the AD1 75 m.p.h. through still air.

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MILITAERWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*September–October*, 1929)—The first two articles, *The Development of Turkish Power* and *The Siege of Vienna by the Turks in* 1529, are published to commemorate the 400th anniversary of Vienna's first successful resistance against siege by the Turks. The editor feels that he ought to apologize for going back quite so far, and excuses himself on the grounds of the wide-reaching results of the Austrian victory, viz., that it saved Eastern Europe from sharing the fate of the Balkan States as Turkey's vassals. This alone might render the achievement important enough for commemoration, even without additional reasons, such as pride in the fact that a town of less than 60,000 inhabitants, the capital of an Austria no larger at that time than the diminished Austria of to-day, maintained itself for weeks against the efforts of a Turkish Empire, extending from Trieste to Persia, from the Don to the Nile, and thence nearly to the Pillars of Hercules. These efforts were expressed in an army 300,000 strong, and containing in 40,000 Janissaries the only regular troops at that time in existence.

Armoured Trains in Action. Three examples of very bold and successful action by armoured trains. They form an appropriate addendum to Capt. Wagner's historical article on the subject, which appeared in the January–February number. The first occurred in August, 1915, on the Austro–Italian front, and was of the nature of a raid, pure and simple, the armoured train breaking through the Italian outpost line and retiring after having shot up Monfalcone railway station. The second example is the destruction of a strong point. This latter was in an occupied tunnel, near Gorizia, and the garrison was 100 strong. The armoured train made a night raid, and made a clean sweep, capturing 10 prisoners, 2 machine-guns, 29 rifles and causing 30 casualties. The third instance occurred in June, 1916, and was the rescue of two Austrian battalions, which, in retiring on Kolomea over the Pruth, had been practically surrounded by the Russians.

The indication appears to be that an armoured train boldly handled may do excellent service by intervening at the right moment in open warfare, and can carry out *coups de main* in static warfare.

Participation by Aircraft in Ground Fighting. Capt. Ritter, late of the German General Staff, treats this subject at first historically, from its commencement by the British in the battle of the Somme to the end of the War, when he describes the way the German fighting squadrons were organized and tactically trained for co-operation with infantry in their great offensive of 1918. He then investigates some foreign post-war ideas on the subject. The Americans, for instance, are trained systematically and thoroughly for flight at the lowest heights, only about ten metres above the ground, using machine-guns and small bombs. As regards the French, the author discusses at some length the ideas of Général Armengaud in his book *Quelques enseignements du Riff en matière d'aviation*, which, carried to their logical outcome, demand the creation of independent air troops solely for co-operation with the infantry in ground fighting, in fact *une aviation de ligne*.

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These ideas Capt. Ritter combats on the grounds of economy, of their sacrificing the strategical co-operation by air forces, or war conduct, to tactical co-operation, or battle conduct; and generally on the ground that ideas of tactical co-operation based upon the French experiences in Morocco, where the enemy was both entirely inferior in armament, and especially was not in a position to undertake offensive counter-measures against the French home territory, cannot be applied to European warfare. He considers that the answer to this question lies in whether, in European warfare, quick tactical success having a decisive effect on the outcome of the War is ever likely to occur. The historical sketch followed by samples of modern ideas is intended to stimulate the reader to think out the problem for himself. As regards what the troops on the ground are to do to guard against low flying aircraft we are referred to Major Angeli's article in *Luftflotten*. (*Vide R.E. Journal*, March, 1929, p. 149.)

Effect of the Heaviest High-Angle Fire Ordnance with Fixed Carriages, by Major-General Ellison-Nidlef. This article has been called forth by Major Heigl's excellent series of articles on the development of artillery material since 1914, which started in the January–February number. It is in the first place an attempt to show that Major Heigl's historical picture of a clear purposeful development of high-angle fire ordnance does not correspond with reality, and that, on the contrary, the development of these weapons has been little thought out and spasmodic. Further, exception is taken to Major Heigl's claim, based upon the capture of the Belgian forts, that only one weapon is decisive, since the fate of a campaign may depend upon the performance and mobility of that one weapon—the heaviest siege mortar. Against this, General Nidlef adduces two lessons from Port Arthur, viz., that brave and skilful defenders, in spite of bombardment by the heaviest artillery, can hold their own; and, secondly, that brave and well led attackers can, even without the aid of the heaviest artillery, break through every position. One is permitted to doubt whether many supporters could be found for either of these propositions. The author himself supports them by citing two examples from his own experience, the first in August, 1915, when the Austrians repelled the Italian attack on the plateau of Lafraun, although it was preceded and accompanied by the heaviest bombardment, and the second in May, 1916, when the Kempel Barrière was captured by an Austrian brigade without heavy artillery assistance.

These are interesting examples, which confirm similar happenings at Port Arthur, but it is not wise to found lessons upon exceptions, or we may find ourselves proving anything, from the utter uselessness of heavy artillery to a superiority of man over material, which enormous casualty lists would easily confute.

As regards books, it is clear that Major Franck is far from agreeing with that Gothic conqueror who, destroying all else, still left the Greeks their books " to consume their vigour and destroy their martial spirit," since he recommends books as character builders, and would have the soldier read in his own time and out of it.

The Development of Artillery Material since 1914 (*continued*). This instalment is full of plums under the sub-title " Some New Inventions."

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They are capped projectiles, the turbo-gun, rifled projectiles and rocket projectiles. As regards the first-named, although armour-piercing projectiles belong properly to the navy and coast defence, the necessity of combating tanks has introduced the capped projectile to field warfare. The author confidently assures all sceptics that even to-day, and on Austria's own frontiers, light tanks are to be found carrying 30 mm. of armour, sufficient to defy ordinary shells. He then describes the Firth cap of soft steel, with concave top covered by a wind hood, which, disappearing itself entirely on impact, causes the same shell to penetrate which without the cap goes to pieces without penetrating. This cap is said to have been improved recently both in England and in the United States.

The turbo-gun was invented by a French lieutenant of artillery in 1917, and embodies a complete revolution in projectile propulsion. As its name implies, it works on the principle of the steam turbine, in that a fairly large charge is subjected to combustion in a chamber so that the gases stream out through a small opening, their potential energy is converted into kinetic, *i.e.*, a great velocity is attained, and they strike the base of the shell and drive it forward, escaping through lateral openings after doing their work.

The inventor promised abnormally high muzzle velocities, and so ranges. He also promised—what in 1921 seemed inexplicable, since muzzle brakes were then almost unknown—reduced recoil, extraordinarily light carriages, and even the possibility of large-calibre automobile guns of extreme lightness.

The French, during and after the War, also the Belgians, then the Americans, and it appears also the Italian Navy, have all had thorough and by no means unsuccessful trials with the turbo-gun. These trials have all been kept strictly secret. Only with the French has publicity been given to certain facts, *e.g.*, that 75-mm. guns and 155-mm. (howitzers?) have both been built. The results with the field gun were most interesting, and even though they did not come up to the inventor's expectations, the astonishing thing is that this entirely revolutionary invention worked at the very first attempt. The reduction of recoil to a minimum, by giving the gas outlets the best shape for the desired braking effect, is a far-reaching advantage of the turbo-gun.

The most promising modern artillery invention is, however, the rifled projectile. The idea originated in France in 1917, and the well-known artillery technician, Général Charbonnier, has been occupied with its working-out for twelve years. Meanwhile, the Germans had put the idea into practice for the 8·4 in. shells of the Bertha built for bombarding Paris at hitherto unheard-of ranges. They found themselves compelled to this step, because no copper driving bands, however broad, could stand up to the rotation accompanying a muzzle velocity of 1,500 metres a second. For the Germans, the matter rested there, and they derived no further advantage from the grooved projectile, which is, of course, expensive and makes loading troublesome. With the French, it has been quite a different story, and Général Charbonnier started immediately attacking the great problems involved.

The results of the trials in figures are staggering. In 1918, in Calais,

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Charbonnier obtained with the 155-mm. calibre a range of 19 kilometres with his shell weighing 60 kilos, against the 16 kilometres for a 43-kilo shell of the normal 155-mm. Field gun results were still more wonderful. The M1900 shell of the C97 field gun weighs 5·4 kilos. Charbonnier fired with the same range and the same precision a shell weighing 12 kilos. Its length was 9·4 calibres, or 27 in. !

After the war, the trials were continued at the Centre of Artillery Studies in Metz, and Charbonnier designed a new 155-mm., known as the 155-mm. gun G.P.C. (Grande Puissance Charbonnier) with all modern improvements, including muzzle brake and the Filloux splayed carriage. Charbonnier is said to have got a range of 32 kilometres with this gun, firing a shell weighing 60 kilos. That happened as far back as 1920. Now it is reported from France that the army is being equipped with a new 155-mm. gun having the range mentioned, but with a shell weighing over 70 kilos. This would seem almost incredible but for our knowledge of what Charbonnier had already achieved.

Against the increased cost of the ammunition must be reckoned the saving on barrel wear. Charbonnier claims that there was no wear after 1,500 rounds.

In the matter of loading, Major Heigl is convinced that Q.F. ammunition will be produced.

The fourth invention, rocket shell, is a revival, since it is quite a century old. In the last few years it has been taken up by three Italian engineers, who have, as with the turbo-gun, obtained very high velocities with very light weapons. The chief trouble is that the shell arrives with less than half the weight it had at starting. There is also the difficulty of the trail of fight or smoke betraying the gun's position. It is not known how far the trials have been a practical success, but we may well obtain also from this an improved performance of the lightest artillery.

The article closes with two appendixes containing extra notes and corrections of certain details of the Vickers' mortars, the British 9·2-in. howitzer and Russian 12-in. howitzer (July–August number) and of the heaviest Italian and American guns (November–December number.)

Infantry Special Weapons, by Col. Fischer. Some plain thoughts upon the necessity of plain thinking. It is putting the cart before the horse to construct a new weapon upon hypothetical grounds and then present it to the troops. This fault, however, is generally made. Whenever a new weapon is about to be constructed, or a new weapon has to be judged upon, there are two points which should be quite clear :—

(1) What do the troops *need ?*

(2) What will the new weapon enable the troops to *do ?*

Col. Fischer puts his finger on the spot, and at the same time shows how the trouble is to be avoided. " Since an infantry company cannot drag about a whole arsenal of defensive weapons for all purposes, stout opposition must be offered to too great specialization and over-construction, and all possible simplification must be striven for. This is possible only when the objects and performances of the weapons are not screwed up beyond the real needs of the troops and beyond what is feasible."

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Psychotechnics and Its Military Significance, by Capt. Fechner. This is another of those hard words, forbidding or intriguing, as the case may be, the meaning of which is perhaps not evident at first sight. The word has been invented apparently to cover the utilization of applied psychology, or as a name for the science of the practical use of psychology. Hence psychotechnics—without its name—has been used as long as men have united in the prosecution of any undertaking, from exploration and the chase to industry and war, or as long as the selection of any man for a job to be done has depended to some extent upon a consideration of his mental characteristics.

Every-day examples are simple mental tests applied to would-be air pilots, girls wishing to become telephone switchboard operators, and candidates for Royal Navy cadetships.

The first example of the use of psychotechnics on a large scale was in 1917, when 1¾ million men in the United States were, in addition to their physical examination, subjected to certain psychical tests to ascertain both their fitness for the army then being raised for service in Europe, and the particular branch to which they should be posted.

These tests, owing to pressure of time, can only have been of the simplest nature, and yet the Americans said that the results were very good.

The Italians took up the idea, and documents relating to tests were found on Italian prisoners after the vast break-through of the Austrians and Germans at Caporetto. The matter was thus introduced to Germany, where it found a warm welcome, and according to Lieut.-Col. Rendulic, in his book *Military Psychological Studies*, the Germans even went so far as to attach psychological experts to the headquarters of the higher commands.

Capt. Fechner in pointing out what has been done already, and how much more may be done to improve and extend these tests, warns us that, precisely in respect to soldiers, psychotechnics has grave limitations, since two of the soldier's most important attributes, character and temperament, are things for which it is very difficult to devise tests.

Types of War Book. After recent "realistic" war books it does one good to read a book like Dr. Meyer's *Experiences of a Regimental Surgeon* (Lehmann's, paper covers, 2 mk. 40 pf.), in which one finds again belief, devotion, hope. These are what one misses in the writings of Mr. Remarque and those of his school—belief in something higher than the individual's small, treasured, self-seeking existence. The author gives us all the horrors, suffering and death, destruction and demoralization, human failure and discontent. He conceals nothing, gilds nothing over. Nevertheless, the war appears quite different from the pacifists' pictures. We experience it once again as a struggle between nations, in which the individual's will to live is subordinated in firm belief and willing devotion. We feel it as the finest and proudest time of the writer's life, when courage, self-sacrifice, faithful service, comradeship, were the pillars upon which one's whole attitude to life was supported.

F.A.I.

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REVUE DU GÉNIE MILITAIRE.

(*May*, 1930.)—In an article called " Economic Work of the Engineers in 1930," an account is given of the military and civil works carried out by the troops of the *Génie* in 1929 under the following heads: Roads and Paths, Bridges, Railways, Transmission, Various.

For example, in August, 1929, a company of the 1st Regiment constructed at Bitche a metalled road one kilo in length, five metres wide, with berms and side ditches.

At the request of the Commune of Deluz, a forest road four metres wide was constructed in the Bois des Charbonniers, by part of the 3rd Battalion of the 1st Regiment.

In September, a detachment of two officers and 99 other ranks of the 6th Regiment was sent to the Department of Ille-et-Vilaine to restore communications, which had been damaged by a series of storms. Amongst other works, they constructed at La Richardais a bridge which included 27 m. of wooden trestles, and 31 m. of ferro-concrete piers.

At the request of a civilian landowner of Pacy-sur-Eure and with the approval of the General Commanding the 1st district, a small detachment constructed a pile bridge over an arm of the Eure.

In Algeria, the 51st Company of the 45th Battalion continued the construction of the railway to the Tunisian frontier.

In March, at the request of a civil contractor, a small detachment refloated an 80-ton dredger which had foundered in a dock at Strasbourg.

An article entitled " Defensive Inundations,"* by Captain Mandaroux, is of interest, in so far as it deals with the inundations in Belgium and Northern France during the War, 1914–18.

THE YSER INUNDATIONS.

The region between Steenstraete and Nieuport forms a polder, the average level of which is two to three metres below the level of high tide. The land is protected by the Nieuport dunes and by locks.

Drainage is assured by a system of canals converging at Nieuport at the mouth of the Yser, where the whole system is controlled by locks. By opening the locks at high tide and closing them at low tide, the sea can be made to flow up the drainage canals and spread over the soil, and can be maintained at a constant level throughout the inundated area.

On three occasions, namely, during the sieges of Nieuport in 1647, 1658 and 1740, resort was had to this method. Nevertheless, no plan existed in Belgium for effecting the inundations; on the other hand, the Germans in their offensive on Calais did not appear to realize the danger which might be caused thereby.

The inundations were carried out progressively, according to the pressure of the enemy advance.

On October 17th, the creek of Nieuwendamme, immediately east of Nieuport, where was the point of greatest danger, had been flooded, but the Germans did not regard this operation—a purely local one—in the light of a warning.

* See also *R.E. Journals* of December, 1928, and March, 1929.—Ed.

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Before the continuation of the enemy advance, conferences were held at the Headquarters of the Belgian Army, and it was decided, on the advice of the engineer officers, to extend the inundation to the east of the Nieuport–Dixmude railway. Preparatory measures were undertaken on the evening of the 25th, namely, the blocking up of the aqueducts and culverts through the railway embankment. During the night October 27th/28th, engineer officers, assisted by pontoniers, opened the lock of the old Furnes Canal, and the sea began to cover the land. Three days later, on October 31st, the Germans were definitely stopped.

The success of the inundations was therefore the consequence of an ordered plan ; but there was an element of chance, in that the operation coincided with the time of spring tides. Eight days earlier or later, it could not have been carried out in the limited period available, as the water would not have attained a sufficiently high level.

The inundation when effected had to be maintained and adapted to the situation. The level had to be adjusted according to military requirements, in particular during the attack on Lombaertzyde in November, 1914. Inundations had to be made to the south of Dixmude, and locks and dikes kept in repair. The railway embankment was breached on several occasions during the winter of 1914–15, and the Belgian frontier endangered. The lock of the Furnes Canal was broken by gunfire, and, after being repaired, finally gave way in 1916 under the effect of scour. It was then replaced by a dam further upstream.

To carry on all this work the Belgian H.Q. organized a Service of Inundations, which included a company of pontoniers (in which were men of special trades, such as divers), a survey branch, a workshop and transport. The principal duties of this service were as follows :—

Clearing the waterways to ensure the flow of water in the areas not inundated. Construction and fixing of automatic apparatus for the daily working of sluices. Protecting banks against scour. Construction of emergency works, in case of destruction by the enemy of locks or barrages on which the inundation depended. Accurate levelling of structures ; organization of a system for taking readings at critical points ; drawing up of a table of tides. All this entailed much work carried out for the most part in the front line, but assisted by the passivity of the enemy.

Action on the part of the Germans was very feeble up to 1917, when destruction by bombardment of banks and other works for retaining the waters was first carried out. The only action which would have proved decisive would have been the destruction by bombardment in October, 1914, of the railway embankment. Directly the waters began to spread to the north of the Nieuport-Dixmude railway, the inundations had fulfilled their strategic role ; the march on Calais had been stopped.

Inundations on the Northern Frontier of France.

Contrary to what had occurred in Belgium, the possibility of forming inundations on the northern frontier of France had been envisaged previous to 1914. The end in view was the creation of an obstacle in the zone of defence of the strong places of this frontier. The plan, which had been revised on several occasions up to 1899, included :

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1. An inundated area in the quadrilateral formed by Dunkirk, Bergues, Gravelines and Calais.

2. An area in the zone of Lille and Douai.

3. An area Scarpe-Escaut (Shelde) in the zone of Condé and the forts of Flines and Maulde.

The organization of these inundations was intimately connected with the defence of the works in the areas concerned; and whilst it was essential to allow for a level of water which would provide an obstacle of military value, care had to be taken to avoid the flooding of an area of excessive extent and difficult to supply, and especially to confine the flooding within the limits of the frontier, which was very near at certain points. Finally, protection by the various garrisons of those works which controlled the inundations had to be assured.

Arrangements in peace time carried out in conjunction with the *Ponts et Chaussées* included modifications to the locks and dikes of the canals; special works such as weirs, culverts, races and shafts, the provision of timber scantlings, piles, pumps, etc.

Works in war time included the construction of dams, channels for flooding, the upkeep of structures, and were carried out by local garrisons.

1. *District Dunkirk, Bergues, Calais, Gravelines.*

The formation of the inundations depended on the utilization of the area of the wateringues, the average level of which was one metre, traversed by the Aa, the canals for drainage towards the sea, and the canals of Haute-Colme and of Bergues which joined the basin of the Aa to that of the Yser. Utilization of the sea-water had been ruled out by a ministerial decision of 1899, except for the immediate defence of Dunkirk.

In arriving at the number and extent of the areas of inundation, consideration had to be given to the necessity for the water being deep enough to form an effective obstacle, and to the fact that the flooding should not encroach on Belgian territory. The use of sea-water being barred, supply had to be obtained: (*a*) from the Aa; (*b*) from rain-water and soakage water, available when the pumps and windmills ceased to pass it into the drainage canals. This latter method admitted of an extension of the inundated area especially below Bergues.

The actual works to be undertaken were:—(*a*) The fixing of the levels of the locks and dikes; in particular, the French portion of the dike of Grandes Moëres; (*b*) The raising of the water level of the canal of Basse-Colme; (*c*) Construction of dams to limit the zone of inundations in the region between Hondschoote and Houthem (nine kilos S.E. of Ypres).

For the execution of the work the Governor of Dunkirk was responsible. A delicate question was raised in connection with the protection of the locks of Wattendam, near Watten, situated outside the Dunkirk area. "These locks placed under the sole protection of the mobile troops, will swiftly fall into the hands of the enemy if the troops suffer an initial check, and the places which are protected by the inundations will very soon fail to benefit by them—just when they most require their assistance." (Report of General Carette, president of the Technical Committee of Engineers, March, 1903.)

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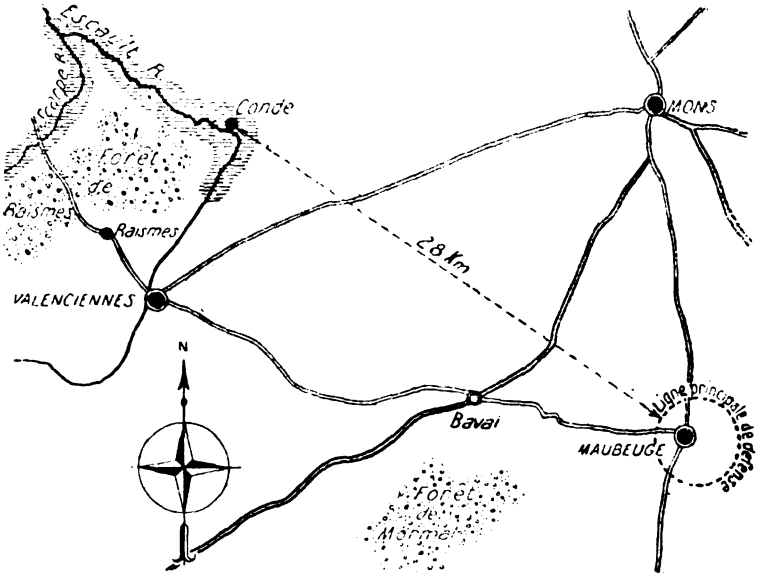
Thus, in respect of one lock arose the question of co-operation between garrisons of points and mobile troops ; the solution had to wait till 1915, when Lille and Maubeuge were in the hands of the enemy.

2. *District Lille–Douai.*

The inundations of this area were limited to the flooding of the ditches of the fortress, to the flooding of the Deule in the area between Don and Wavrin, " without interrupting the navigation of the river."

3. *District of the Scarpe and Escaut* (Schelde).

The supply to the different basins was assured by the Escaut, the Scarpe and their tributaries. Numerous dams and races had been constructed in peace time, others had been planned for mobilization so as not to hinder navigation.



POSITION VALENCIENNES-MAUBEUGE

Of these three systems of inundation, only that of Dunkirk-Bergues was effective during the War of 1914–18. Between August 5th and 25th, the Governor of Dunkirk had the works strengthened. On the latter date, flooding began with the Uxem basin and was continued till October 5th. The other basins were flooded in September and October, and the inundation was maintained till December, by which time Dunkirk was no longer in immediate danger.

With the German attacks in the spring of 1918 the question of inundation again arose. A note of G.H.Q. of April 12th, 1918, marked out for inundation the basin of Dunkirk-Bergues, reinforced by the area St. Omer. The flooding was carried out between April 12th and August 17th, but was very difficult to maintain on account of the dry weather. In the event of a break on the Belgian front the inundation of the area between the Nieuport-Dixmude railway and the Canal de Loo was contemplated.

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Of the other systems of inundation on the northern frontier, that of Lille-Douai had only the value of a local obstacle easily surmountable. The same cannot be said of the system Scarpe-Escaut. One can imagine what assistance it would have brought to an army retreating from Mons towards the south-west, intending to establish itself between Valenciennes and the forest of Mormal with its right resting on Maubeuge, its left on the forest of Raismes covered by the inundations Scarpe-Escaut. But the armies operating in 1914 knew no more about the schemes for inundation than they did about the fortresses.

When studied in detail, the French schemes for inundations seem to rest on too narrow a general plan. It relegated them to the part of obstacles to the permanent fortification, whilst the field armies did not know of their existence and could not profit by them.

Such as they were, they could have been used to better purpose, with results comparable to those obtained by the system of Dunkirk, which on two occasions, in 1914 and 1918, played a role in the protection of Dunkirk and Calais similar to that of the inundations of the Yser.

A.H.B.

REVUE MILITAIRE FRANÇAISE.

(*April*, 1930.)—Général Lemoine completes "*En relisant Clausewitz*" in this number. Having already dealt with the various stages of war which go to make up war as a whole, he now deals with the complete plan to be made at the outbreak of war. The three plans, complete offensive, restricted offensive, and defensive, are considered in turn, and as an example, Clausewitz's solution to an attack on France by a European coalition is considered. The writer concludes with the opinion that, although modifications since 1830 have been many, Clausewitz's ideas can still be adapted to modern conditions.

Lieutenant-Colonel Vauthier completes his important article, "*La défense du pays contre le danger aérien*" in this number. He first discusses the organization of the defence, a complicated problem to which it is hard to see the correct solution. In Italy, the Chief of the General Staff has control over all methods of war, and naturally, air defence comes under him; but in countries like England, where the Air Ministry and War Office, to say nothing of the Admiralty, are co-equal, a solution similar to the Italian will not work. Lieutenant-Colonel Vauthier sets out very clearly the complexity of the problem and the efforts made in the various countries to deal with it. The writer then concludes by pointing out that no one defensive method can be effective by itself, and points out how many branches of life, civil as well as military, are concerned in air defence. There is no doubt that in the future, any country going to war, without adequate air defence, is asking for defeat.

In Commandant Loup's interesting article, "*La famille Musulmane au Maroc*," the outstanding features of a Mohammedan family, as applied to marriage, birth and death, are described. The Mohammedan differs from the Christian in that the man is absolutely pre-eminent in his family, while the women are regarded purely as bearers of children,

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and otherwise of little account. Commandant Loup indicates the life of women in the various tribes of French Morocco, and describes the religious part of birth and death, as governed by the Koran.

Colonel Revol completes "*Initiation au voyage militaire des Alpes*," with a description of the systems of fortification built during history, and of the offensive and defensive operations fought up to the time of Napoleon, who wrote the following: "In the mountains, one finds everywhere a number of positions which are extremely strong and appear impregnable. The genius of making war in this country is to occupy positions on the flank or in rear of those of the enemy. Thus he only has two alternatives, either to retire without fighting or to attack." This lesson is so true that it should always be remembered. At the same time one must realize that special training is required for mountain warfare, and Colonel Revol concludes his article by stating that the country must be organized while the troops and the leaders are trained.

Lieutenant-Colonel Pugens completes "*Rossignol*" in this number. By the end of the action the Germans had been completely successful near Neufchâteau, in spite of a most valiant resistance by the French. The description of the fighting is not particularly interesting, but the writer has some useful comments to make. Although the German information was inadequate, the units were well trained to come into a battle formation quickly and to obtain information before becoming involved. They were also well trained for fighting in the woods. The French, however, showed a fatal tendency for attacking into pocket-holes from whence they were unable to escape. In fact, as pointed out by Lieutenant-Colonel Pugens, once the two forces become involved, it it is the lower commanders and troops who succeed or fail, and these must be well trained in peace or they will fail in war.

(*May*, 1930.)—Lieutenant-Colonel De Boisboissel begins "*Les opérations au Maroc*" in this number. This is a most interesting article, dealing with conditions which correspond enough with those of our own N.W. Frontier to make it worth study by British officers. This instalment deals with the enemy and with the efficiency of the various arms. The writer points out at the beginning that, in Morocco, the enemy of to-day is the friend of to-morrow, and therefore he must be defeated but not crushed. This particularly affects the use of artillery for general bombardment, and we may compare the use of our own aircraft in India. The writer then considers the work of the various arms, and it is interesting to find that he does not regard tanks as an unmixed blessing. In fact, certain parts of the country are so difficult that the presence of tanks rather delays than accelerates the infantry, who have the hardest work, as usual. Colonel De Boisboissel finishes with a short description of the various local levies, which again may be compared with our Khassadars on the N.W. frontier.

In "*La motorisation dans l'armée des Etats-Unis de l'Amérique*," Capitaine Cammas begins with a very short description of mechanization in England, followed by an indication of the different types of mechanical vehicles in the American Army. As he points out, both England and America, being industrialized countries with small professional armies, have naturally turned to mechanization for the improvement of their

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armies. In this instalment, the writer merely explains what types of vehicles, armoured or otherwise, are used in America, after describing how our own Armoured Force was formed.

In Lieutenant-Colonel Morin's "*De l'utilité de la fortification permanente,*" the value of the fortifications of N.E. France is clearly set out. Colonel Morin is evidently a believer in permanent fortification, and he certainly does explain how the big fortresses both provided bases for operations for the French and also affected the German strategy. The great attack on Verdun was carried out on account of its value to France, while the original German plan of operations was partly caused by the forts covering the Belgian frontier having been neglected. It is probably generally realized that fortifications, if properly designed, will always be of value in trench warfare, but Colonel Morin considers that under all conditions, these fortifications, owing both to their material resistance and to their moral effect, will always be of great importance.

"*Guerre de mouvement et ravitaillement,*" by Intendant militaire Chaumont, is a discussion of the method of supply to be employed in mobile warfare in the future. As the writer points out, supply was comparatively easy during the Great War, owing to its stationary character in the west, but in future we cannot anticipate a continuation of trench warfare. Without going into any details, the solution suggested is that the supply units of each division should be partly horsed and partly mechanized, so as to be able to work in any country, while a reserve on wheels should be provided for divisions in case of emergency. The composition of this reserve is not discussed in this article, but its provision is put forward as providing the best type of reserve for contingencies which are bound to arise in war.

Capitaine Tourret begins an interesting article, entitled "*L'armée espagnole du Maroc,*" in this number. He first describes the country briefly, and then the early stages of conquest of Morocco by the Spaniards, four or five hundred years ago. The rest of this instalment touches briefly on the recent disturbances, culminating in Abd-el-Krim's revolt, which was finally defeated by the French and Spanish after an agreement between the two countries in 1925. Capitaine Tourret concludes the instalment with a short description of the vast effort required by Spain to maintain the necessary troops in Morocco.

(*June*, 1930.)—"*Du caractère,*" by Commandant de Gaulle, appears in this number. The article is based on the theme that the French Army cannot live just by a prudent attention to the situation at any time, but that its leaders must have the character to act in defiance of orders when necessary. He quotes Lord Fisher's remark after Jutland about Lord Jellicoe: "He has all Nelson's qualities except one: he cannot disobey." We all know that there are occasions when something more than obedience is required, and Commandant de Gaulle writes to draw attention to the determined spirit of men like Napoleon, who did not obey rules, but who brought the French Army to its highest pitch of enthusiasm and efficiency.

Lieutenant-Colonel de Boisboissel continues "*Les opérations au Maroc*" by describing the action of mobile columns, the establishment of posts, and the construction of roads or tracks. It is interesting for us

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to compare our own operations on the N.W. frontier of India, as there is a similarity throughout. The French favour a mobile column based on six battalions, which is neither too weak nor too strong, and which can carry out extensive operations. The writer describes the various stages of operations by these columns, and each stage has its counterpart in India. He then goes on to posts, and their construction in this wild and desolate country, and one of the first things mentioned is that the post must be enclosed by a stone wall, just as in India. He finally touches on the construction of roads and tracks, based on a careful reconnaissance. To us it seems possible that the provision of good roads may have the same pacific effect in Morocco as it has had in Waziristan.

Capitaine Cammas completes "*La motorisation dans l'armée des Etats-Unis*" in this number. A series of manœuvres carried out by completely mechanized units are described, and the writer then goes on to indicate the progress of mechanization in the various arms. Capitaine Cammas' conclusions are of interest to the Englishman, as he generally compares mechanization in the British and American Armies. Both countries are the only ones to attempt manœuvres with purely mechanized units, but the writer points out that in England we are ahead of the Americans. The General Staff at our War Office has issued provisional regulations on the use of armoured vehicles, while this has not yet been done across the Atlantic. Again, Great Britain is ahead of the United States in considering complete armoured brigades, rather than infantry brigades put into mechanized transport. There is no doubt that, owing to their own types of army, these two countries are bound to take the lead in mechanization.

"*La Ire Armée française à la bataille de la Serre*," by Commandant Thierry d'Argenlieu, is a description of one of the operations which helped to make up the great advance of the Allies in the autumn of 1918. General Débeney's 1st Army, on the right of the British, naturally was of particular importance to us; but the description given is of little interest except to someone who was actually taking part or who knows the country. The article is illustrated by three maps.

Capitaine Tourret completes "*L'armée espagnole au Maroc*" in this number. A considerable part of the instalment is devoted to a description of the actual organization of the Spanish forces in Morocco, but the writer's conclusions are of interest. From 8,000 troops before the rebellion, the forces employed rose to no less than 160,000, and are now as much as 75,000. Capitaine Tourret pays a well-deserved tribute to the efforts made, both economic as well as military, to pacify the country, and he looks hopefully towards the future in Spanish Morocco.

H.A.J.P.

THE MILITARY ENGINEER.

(*July–August*, 1930.)—Major William M. Robinson, jun., contributes an interesting historical article on "The Confederate Engineers." We learn with malicious satisfaction that "the engineers were not mentioned in the General Staff Act of 1861," and that the first two Acts for

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raising volunteer forces omitted the Engineers entirely; they only became "permissible"—(what a concession!)—under the terms of the third Act. We rub our eyes and wonder if we are really reading about the crisis of 1861, or if we are merely listening-in to the hatching of a tactical exercise in 1930. "I suppose we had better put in some Engineers . . . not too many of course . . . goodness knows what they are going to do. . . ."

However, the Corps was recognized at last, and was given an establishment of ten officers and one Company. It seems that the officers did not form part of the Company, which was organized strictly for work. Thus, the sergeants were called *master workmen* and the corporals *overseers;* the privates of the first class were called *artificers* and those of the second class *labourers*. Two musicians were included, but in the absence of the appropriate G 1098 we cannot tell how they were equipped, nor do we know whether they were men of the first class or merely labourers.

A "Sapper and Bombardier Company" was next formed, thus raising the proportion of Engineers in the field army to one per cent. Small wonder that, in December, the Secretary of War complained of the paucity of Engineer troops. Congress accordingly proceeded to consider a Bill for raising four battalions of pontoniers, but did not succeed in passing it. In March, 1863, however, they authorized one Engineer company per division, and the comment is made that in so doing they had acted with "all reasonable promptitude."

An interesting exchange of opinions took place on the subject of forming the Divisional Engineer Companies into regiments. General Lee admitted the value of Engineer troops, but maintained that, by keeping them together by battalions and regiments, the Divisional Company would never be on hand when the Division needed it. To this Secretary James A. Seddon replied:—

"Is this objection well founded? In order to give dignity to the service, as well as *esprit de corps* to officers and men, will it not be eminently proper, whenever the army is in camp for any length of time, and no immediate movement or attack anticipated, that the companies should be brought together regimentally? It seems to me it is only thus that the field officers can have sufficient control and influence; only thus in great emergencies, that these troops can be made to act harmoniously together in large numbers, and that they can ever be of service as armed soldiers.

"If they are to be kept simply and always in company organizations, subject exclusively to the orders of the Major-General commanding the division, the probability is great that they will rapidly degenerate into mere drudges, scarcely better than camp-followers, to be employed in menial service, burying the dead, etc. As a natural consequence, the better class of officers (and great efforts have been made to secure efficient and accomplished ones) will soon resign, rather than be attached to a non-fighting corps of very mediocre reputation."

The Corps acquitted itself with distinction, and many of its members attained high rank as general officers.

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Captain Kohloss gives an account of searchlight development, and describes the latest mobile unit, known as Model M-VI 1930. A truck type of power-plant chassis is provided, which carried the searchlight, comparator and crew, and tows the sound-locator and its detachment.

Among the articles which deal with Civil Engineering, there is an account of the laying of asphaltic-concrete roads in aviation camps, where the prevailing low temperature precluded the use of concrete or water-bound macadam.

The " Mammoth Saluda Dam " is an example of the semi-hydraulic fill type of dam, that is, one formed of two dry outer walls and a core of sluiced clay. Full details are given of the power plant and the article is well illustrated by photographs.

In an editorial review of the Indian situation, the problem of India is referred to as a world-problem. Later, however, the view is expressed that " we cannot criticize a colonial Power intent on retaining what it considers as its own. . . . One must admire the forbearance and adroitness with which the British are handling an exceedingly delicate problem, although this might have been expected from a people who have so uniformly demonstrated such wonderful efficiency as colonizers."

O si sic omnes!

I.S.O.P.

CORRESPONDENCE.

ENGINEER TRAINING IN NEW ZEALAND.

A CORRESPONDENT, Major W. A. Gray, of the N.Z.E., has kindly forwarded the following notes and photographs reproduced herewith :—

" This year, the Northern Depot, N.Z. Engineers, carried out their six days' annual camp at Ngaruawahia with a strength of 10 officers, 35 N.C.O.s and 160 men.

" The nearest waterway is the Waikato River, which, in this locality, is two hundred yards wide, up to twenty feet deep, with a current of three–four knots.

" The main bridging exercise was the construction of a flying bridge, composed of a pontoon raft, swinging on a cable which was anchored some 600 yards upstream.

" The accompanying photographs show the bridge in operation during the inspection of the unit by Major-General R. Young, G.O.C. N.Z. Military Forces.

" The average rate of movement of the raft was three minutes from stage to stage, the speed being greatly increased by the addition of a lee-board.

" The river work was made easier by an improvised motor-boat ; an 8-h.p. outboard motor on a stern bracket was added to a standard old-pattern pontoon. Unloaded, an average speed of 11 knots was obtained, and the craft handled well in all conditions. The maximum load carried was 22 men.

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"An assault-bridging night operation was carried out, enlivened by smoke, guncotton 'shell-bursts,' blank ammunition, and Very lights. Apart from the training value, the affair was a real 'Brock's benefit' for the local inhabitants.

"The normal training in demolitions, use of spars, entrenching, etc., was also carried out."

Another letter on this subject has been received from Lieut. E. C. Schnackenberg, N.Z.E., who writes:

Onehunga, Auckland, New Zealand,
5-4-30.

DEAR SIR,

* * * * * *

"I have been away from home for the past seven weeks at Trentham Military Camp. I was one of those four lucky Territorial officers who, together with five N.Z.S.C. officers, were chosen to take to Samoa 250 men of the Samoa Military Police. However, after five weeks' training at Trentham, we were demobilized.

"We had a very successful Depot Camp this year. Our most interesting job was the erecting of a flying bridge across the Waikato. The river was 250 yards wide, about 20 feet deep, and had a 5-knot current on one side. We were helped by motor launch, made by fitting a 7 h.p. Elts outboard on a wooden bracket at the stern of a wooden pontoon. We got about 8 knots out of the craft, and travelled about 50 miles during the course of the camp."

SCIENTIFIC SOLDIERSHIP.

The Editor, The *R.E. Journal*.

DEAR SIR,

Some time ago you allowed me, through the medium of your pages, to put some questions to Brigadier Fuller on an article by him entitled "Scientific Soldiership," drawing attention to flaws in his reasoning which appeared to me to upset the conclusions he arrived at.

Theories, similar to those on which that article was based, are expounded in the paper entitled "The problem of the Last 800 yards," printed in your last number, and as similar flaws reappear in this, and seem also to permeate nearly all current literature on the subject of armoured warfare, I hope you will once more accord me the hospitality of your columns to draw attention to them.

Brigadier Fuller says (page 207), "above all we want a mobile force," and a little earlier he asks, "how can we resuscitate the mobility of infantry?" He replies, "tactically by armour . . . armour is the enemy of the bullet." Unfortunately armour is also the enemy of mobility, although he omits to say so, and the omission is significant in his argument.

He goes on to say, "half an inch (of armour) is what we want. It

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ENGINEER TRAINING IN NEW ZEALAND.

Raft loaded with Staff, half-limber, and superstructure for far landing bay at near stage.

The completed raft for swinging, with lee board. C.O., padre (in cap), and Coy. Mascot.

Assault Bridging—built locally. Site of night operation.

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Half-limber being lifted off far stage on to road—which was cut into hill on edge of river. Colonel Duigan (C.S.O., Northern Command), and Captain Clifton (Adjutant), in centre.

The motor-boat (improvised locally). An 8 h.p. "Johnson" on a 14" stem bracket bolted to stem of pontoon. Did 15 knots with, and 9 against, current, as loaded here. Controls brought to wheel in stern.

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may not keep out the heavy bullet or shell, but this is not the immediate problem . . ."

Unfortunately, if it is not the immediate problem, it is certainly the only one of any interest to the soldier, for otherwise we are left considering the action of tanks against an enemy who can neither run away from, nor injure them. Under such conditions no one will disagree with Brigadier Fuller that tactics will degenerate into mere " hunting the enemy," but we should lose interest in them.

Brigadier Fuller, however, himself contradicts his statement when he says later, " if frontal fire is too strong, they (*i.e.*, the tanks) swing to a flank." Here obviously he is considering the fire of " heavy bullets and shells," for fire consisting only of bullets which will not penetrate the tank's armour can hardly be called " too strong."

Any fire which is too strong for a frontal attack must surely be too strong also for the " swing to a flank." If tanks can escape the consequences of a too rash advance by such tactics, cavalry should have been able to do so also. He adds that they will " draw fire and deliver fire," and help the infantry to advance thereby, but as the only fire they are likely to draw is that of the anti-tank armament, and the fire they deliver has to be aimed at an enemy about which Brigadier Fuller has just said " all they know is the area from which fire is coming," it takes rather more than an optimist to believe that their action will produce the effect he expects.

In short, Brigadier Fuller suggests that if only a man will get into a tank, where he will be well warmed and shaken up and has only a small slit in an armoured plate to look through, he will see better and shoot straighter than an infantry soldier at targets which, as he himself says, " the infantry themselves can seldom see."

The argument is characteristic of many adduced in support of armoured warfare in its assumption that even if the enemy takes the elementary precaution of providing himself with anti-tank weapons, he will exhibit no skill whatever in their use. As Lieutenant-Colonel Baird-Smith says in the *R.U.S.I. Journal* (May, 1930, " Theory and Practice of Mechanization "), " there is hardly a limit to what an armoured force might be conceived as accomplishing given a sufficiently stupid enemy."

As to the " Problem of the Last 800 Yards," Brigadier Fuller asks if reliance can be placed on the artillery, and says that the answer is " obviously no." This answer is by no means obvious. Indeed, if the experience of the Great War is to be believed, the answer should be " certainly yes." At any rate, it can be stated as a fact that eventually the artillery succeeded in solving the problem in the last War. It is possible that if they were given the chance they might do so in the next. How they should do it is, as Mr. Kipling says, " another story."

Yours, etc.,

M. N. MACLEOD.

25th June, 1930.

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SIXTY YEARS AGO.

THE

ROYAL ENGINEER JOURNAL.

FOR PRIVATE CIRCULATION ONLY.

AUGUST 1ST, 1870.

AQUATICS.

ROYAL ARTILLERY *v.* ROYAL ENGINEERS.

On Monday, July 11th, the second of what will, it is hoped, prove to be a series of Annual Eight-oared Matches between the Officers of the sister Corps, took place at Putney, the course being from opposite Putney Pier to a Flag-boat moored about 100 yards above Chiswick Eyot. As will be seen by the following account of the Race the Sappers have on this occasion retrieved the laurels which they lost last year—with a few to spare—and this fact is, they feel, principally owing to the great care and attention of Mr. W. W. Wood, of University College, Oxford, who kindly undertook and ably performed the onerous task of coaching the Crew into something like good form, and whose labours have on this occasion resulted in the Corps being able to turn out a very creditable representative Crew. It is right here to mention that whenever Mr. Wood was prevented from attending, his place was filled by either Mr. Darbishire, Mr. Chambers, or Mr. Hall to each and all of whom the thanks of the Corps are due, and we may add were paid by that Officer of all others whom the Corps would wish to be their Spokesman, and whose thanks would be considered the most valuable—we mean Field Marshall Sir J. Burgoyne, who was, to the delight of all present, on board the Umpire's Boat during the Race, and who evinced the greatest possible interest in the proceedings throughout.

The Royal Artillery were as last year coached by Mr. W. B. Woodgate.

The following are the names and weights of the two Crews—

	ROYAL ENGINEERS.	st.	lb
1	W. W. B. Whiteford	11	4½
2	C. Hoskyns	11	7
3	W. W. Darby	11	1
4	J. C. Barker	11	7½
5	A. Bogle	12	1
6	C. H. Brookes	11	10
7	A. F. Preston	11	13
	J. F. Brown (stroke)	11	5
	H. W. Clarke (Cox)	8	10

	ROYAL ARTILLERY.	st.	lb.
1	H. N. Jones	10	10
2	J. K. Trotter	10	11½
3	A. Logan	11	6
4	J. V. Baker	12	0
5	H. E. Preston	12	8
6	C. Le Mesurier	11	0
7	C. Larcom	12	0
	F. A. Aylmer (stroke)	10	5
	C. Jones (Cox)	8	12

The above Crews with the exception of Captain Le Mesurier, who at the eleventh hour took the place of Mr. Eustace Malpert on account of

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the latter Officer having hurt his hand, had competed for the Thames Cup at Henley Regatta, but unsuccessfully—although the performance of the Royal Engineers has been very satisfactory.

The start was fixed to take place as soon after noon as possible, and at a few minutes before that hour the Umpire's Boat took up her position in rear of the starting point, having on board in addition to the Umpire, Mr. W. Benson the President of the Oxford University Boat Club, Field Marshall Sir J. Burgoyne, Bart., G.C.B., R.E., Major-General Sir L. Simmons, K.C.B., R.E., Major-General Gambier, C.B., D.A.G., R.A., Major-General Brownrigg, C.B., Col. Hnble. H. F. Keane, D.A.G., R.E., Col. Herbert, C.B., A.A.G., Col. Gallwey, R.E., Mr. Woodgate, Mr. Wood, and about 20 others. Two other Steamers having on board over 200 Officers of the Corps with their friends followed the Race.

At 20 minutes past 12 the rival Crews paddled down to their Stations, the Royal Artillery who had won the toss selecting the outside berth. Mr. Searle officiated as Starter and after asking the usual preliminary question, without receiving any response dismissed them on level terms at the first attempt. Directly the signal was given the Gunners dashed away at a tremendous pace, rowing something like 47 strokes to their opponents' 39 and at once showed with a lead of a few feet which they increased to a third of a length half-way between Simmonds's and the London Boat House. The pace, however, was too hot to last and just above Bishop's Creek the Sappers, rowing a long steady stroke, came up to the leaders, and after rowing oar and oar for about a dozen strokes drew out hand over hand showing a clear lead just above the point. Between this and the Crab Tree they increased their advantage by another length and at the Soap Works point were fully two lengths to the good. At Hammersmith Bridge which was reached in 7 min. 58 sec., from the start the Royal Engineers had placed upwards of three lengths to their credit and were rowing well within themselves, while the Royal Artillery were all abroad and rowing wildly and the race was to all intents and purposes over. At the Doves the Coxswain of the R.E. Boat for some inexplicable reason took them right over towards the Chiswick bank which enabled the others to draw up nearly a length.

The error was however of no moment as the Gunners were at this point utterly incapable of making an effort while their opponents were to all appearance as fresh as when they started.

Half-way up the Eyot the R.E.s spurted and coming right away landed themselves easy winners by three good lengths which but for the faulty course between Hammersmith and the finish might have been doubled.

The time from start to finish was 12 min. 49 sec.

SHELTER TRENCHES.

A shelter-trench is an excavation in a continuous line (earth thrown to the front) whereby hasty temporary shelter is provided for troops in line, and as such it comes under the heading of " Temporary Field Fortification." Fortification may be defined as the art of protecting combatants while preserving their fighting powers, and thus, by lessening their adversaries' power of inflicting injury, it strengthens or fortifies that side which employs it. * * * * * * *

By the introduction of the breech-loading rifle, the shelter trench has

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acquired much greater importance, since, with that arm, the soldier (while himself protected) can load and fire without betraying himself by any motion; and, while keeping his rifle steadily resting on the parapet, he can (if it be a Martini-Henry) load and fire at the rate of twenty to twenty-five rounds a minute if rapidity be required, or with deliberate aiming, he can attain great accuracy up to 1,200 yards. * *

The form of trench approved by the Drill Committee is 15 inches deep, 2 feet wide, with a parapet about 15 inches high. This will screen two ranks from sight—one in the trench and one lying behind. It will also, to a great extent, as already stated, protect them from fire. It can be made in from ten to twenty minutes, according to the nature of the soil, or, if more time be available, it may be widened to four feet in from ten to twenty minutes more, or to seven feet with a total labour of from thirty to sixty minutes. This trench offers no obstacle to troops advancing, and is, therefore, available when they are required to act on the offensive. Skirmishers' shelter-pits can be made in much less time, from two to four minutes being sufficient to obtain cover for one man lying on his side ready to fire or to crouch down, the pit being cut not more than two feet three inches broad in front and 1 foot 3 inches in rear, so as to just fit the body and legs of the skirmisher. * * *

It is obvious that the introduction of this system into European Armies will produce a complete revolution in the tactics of future warfare; yet, if we consider the matter, we shall find that it will necessitate less change in our own method of fighting than in that of Continental nations. This arises from two causes—firstly; that, as our troops are accustomed to fight in line, there will be no change of formation required in advancing from a line of trench, as will be the case with troops trained to attack in column; and again for us there will be nothing unusual in receiving a charge in line. In fact, the line being our order of battle, our troops are at once ready to advance or retire from their temporary cover without previous concentration or deployment. Another reason for our troops adapting themselves readily to the shelter-trench system is to be found in the fact that their temperament and discipline disposes them to excel in that system of tactics adopted by the Duke of Wellington, called by the French, "*La defense avec retour offensif.*" Acting on this system, the Duke was in the habit of keeping his troops as far as possible under cover behind the crest of a ridge, a hedge, or any other natural cover that might be available; then to allow the enemy's columns to approach pretty close—pour in rapid fire (*feu d'enfer*), and, when the columns get disorganized, charge them with the bayonet. These were precisely the tactics of Picton's division against the grand left central attack of the three French columns at Waterloo, where he received them with Krempt's Brigade drawn up in line behind the hedge along the Wavre road. After firing a volley the brigade charged, but were disordered in getting through the hedge (especially the 79th Highlanders, who suffered severely), and here Picton was killed. Now these, the tactics of our greatest general, will be the tactics of the future, but our troops must be trained not merely to take advantage of natural cover, but to supplement it by artificial cover, taking care always that when offensive movements are contemplated they should neither choose nor create cover giving obstacles to their advance.

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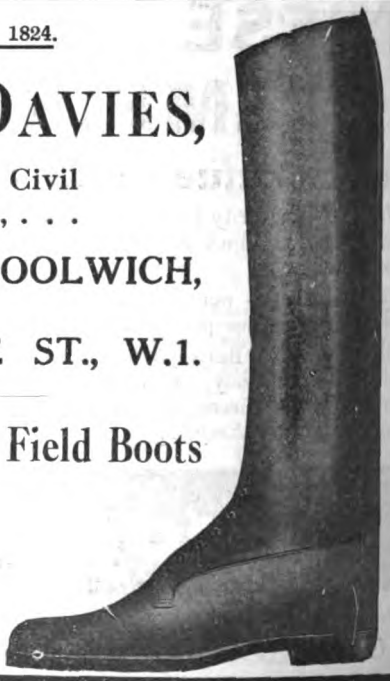

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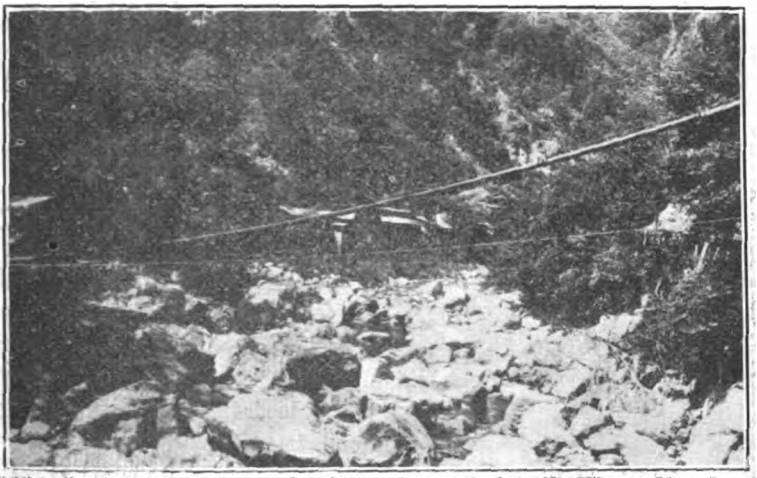

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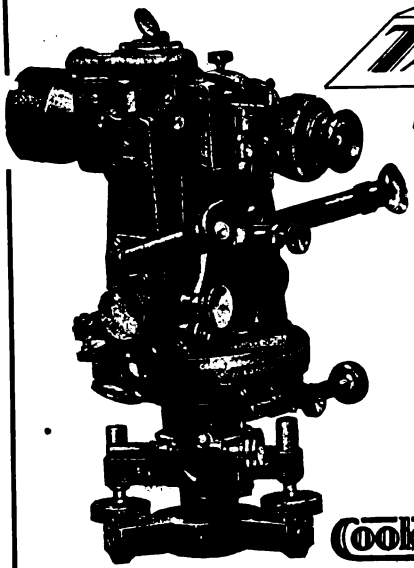

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GENERAL SIR CHARLES WILLIAM PASLEY, K.C.B., F.R.S., D.C.L.

1780—1861.

Frontispiece to R.E. Journal.—December, 1930.

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SIR CHARLES PASLEY.

1780 *to* 1861.

I.

HIS LIFE: A SKETCH.

By LIEUTENANT-COLONEL P. H. KEALY, R.E. (*retired*).

THE history of the Corps of Royal Engineers since its formation as a separate body in 1716 may be divided into four periods, the third of which is perhaps the most important and interesting. Corresponding with important landmarks in European history, this period may be taken as extending from 1793, the beginning of the long war with the French, till the end of the Crimean War, when the Board of Ordnance ceased to exist.

There were two dominating personalities in the Corps during that period, Sir John Burgoyne[1] and Sir Charles Pasley[4]; they were contemporaries, Sir John being some eighteen months younger, but were widely different in character, and exercised their decisive influence on the development of the Corps on different lines.

This year is the 150th anniversary of the birth of Sir Charles Pasley, and it is proposed to give a sketch* of his life, and then to deal in more detail with some of his many outstanding activities.

Born at Eskdalemuir, Dumfries, on 8th September, 1780, Charles William Pasley was the son of Charles Pasley, merchant of London, and, as one of the family, was consulted by his elders and became a leader amongst his contemporaries. The two families of Pasley of Craig and Malcolm of Burnfoot (cousins) produced in two generations one baronet and seven knights. This outburst of brilliance is perhaps due to Sir Charles Pasley's grandmother, Magdalen Elliot, who traced her descent from King Robert III. of Scotland. **1780**

* The writer is largely indebted to British Museum MS. 41766, being a life of Pasley by Colonel John Charles Tyler; to *The School of Military Engineering*, 1812–1909, by Col. B. R. Ward; to the same author's 5th edition of Pasley's *Essay;* to Porter's *History of the Corps of Royal Engineers;* to Jones' *Sieges in Spain;* and to original letters and Jones' Diary in the R.E. Museum.

[1] John Fox Burgoyne, Bart., G.C.B. 2nd-Lieut., 29.8.1798. General, 5.9.1855. Field-Marshal, 1.1.1868. Died 7.10.1871. *War Services:* Malta, 1800; Sicily, 1806–7; Egypt, 1807; Sweden, 1808; Peninsula, 1808–9 and 1809–14; New Orleans, 1814–15; France, 1815–18; Portugal, 1827–8; Turkey, 1854; Crimea, 1854–5. I.G.F., 1845–68.

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Admiral Sir Thomas Pasley, 1st Baronet, was uncle to Sir Charles, and commanded a Division under Lord Howe on the Glorious First of June, 1794.

Pasley was a good classical scholar at an early age, but apparently learned little at the local school he attended. He joined the Royal
1796 Military Academy in August, 1796, and was nearly expelled for
1797 practical joking. On the 1st December, 1797, he received his commission in the Royal Artillery and joined at Woolwich. Writing home soon after he says, "At this time, when every body of men are subscribing for the defence of the country, our Regiment has not been the last—the officers each six days' pay and the non-commissioned officers and privates three days' pay." A similar contribution is recorded by Connolly as having been made by the Royal Military Artificers.

1798 On April 21st, 1798, he was transferred to the Royal Engineers, for which Corps he had been intended from the first. He was posted to Portsmouth, where amongst other works he was employed on the building of Fort Monckton, and started the career which he followed "with that sort of headlong ardour that I believe has been a part
1799 of my character from boyhood." In March, 1799, he sailed for Min-
to orca, where he was busy with fortifications for two and a half years.
1801 In 1800, Sir Ralph Abercrombie passed through Minorca on his way to Egypt, and was so struck with the character of Pasley, whose acquaintance he made there, that he would have taken him with him to Egypt had not Capt. D'Arcy,[2] the Chief Engineer, said he could not spare him.

The Peace of Amiens lasted from 1801 to 1803, the terms of which were most distasteful to Pasley at the time, as to many others, and in his later writings he especially condemned the handing back of Malta to the Knights of St. John; one of the many occasions in our history when, seemingly, the government of the day has not realized that in their effort to display a generous spirit to the late enemy they must needs betray or be less than just to their friends.

1801 In November, 1801, Pasley was ordered to Malta, where he found his friend Burgoyne.[1] During 1802, he visited Egypt on leave, and was back again in Malta when war was once more declared. He wrote, "I had yesterday the pleasure of receiving your letter by the *Amphion* frigate which brought out Lord Nelson and the welcome news of war. I have not yet been able to see the celebrated character, who was received on his landing by the loyal acclamations of the Maltese, being no less a favourite with the multitude here than in England. He took seven prizes by the way and sails in a few days to assume command of our fleet before Toulon."

[2] Robert D'Arcy, C.B. Lieut., 17.1.1776. Maj.-Gen., 12.8.19. Died 13.5.1827. *War Services:* Minorca, 1781; Portugal, 1798; Minorca, 1798; Copenhagen, 1807; Walcheren, 1809,

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During the time of the Toulon blockade which Lord Nelson maintained from 1803 to 1805, Pasley was sent, in 1804, to report himself 1804
to the Admiral and to examine certain engineering questions in connection with the proposed fortification of the Magdalene Islands. "I had long had a great desire to behold this illustrious character whose heroic deeds have filled the world with astonishment, and will form the admiration of posterity. His appearance, a thin, middle-aged figure, would be by no means striking if the want of an arm and a shade over one eye did not suggest to you the memory of the high services he has rendered to his country. Who would not be content to lose a few spare limbs, and life itself, to have rendered such services! Our conversation was short and commonplace, and I did not sit near him at dinner, but I remarked the keenness of his look and gesture which announced the decision of his soul." Pasley was also much struck by "the zeal of the captains of the Fleet, and how interested they seem in everything concerning their ships and men, which appear entirely to engross their minds."

Pasley was with our force which went on the expedition to help Naples in 1805 and which retired to Sicily on the Russians with- 1805
drawing from the undertaking. Sir John Stuart in 1806, seeing how 1806
careless and swollen-headed the French Commander had become, decided to strike a blow, and embarked a force of 5,000 men at Messina which landed in Calabria to create a diversion in favour of the garrison of Gaeta, which was holding out gallantly against the French. The Engineers who accompanied the force were Captain C. Lefebure,[3] Commanding Engineer, Second Captains C. W. Pasley[4] and J. T. Jones,[5] Lieutenants G. Lewis,[6] W. Nicholas,[7] G. Macleod,[8] and G. C. Hoste,[9] a band of outstanding officers all of whom either earned high distinction and honours or suffered gloriously at the sieges in the Peninsula. The result of the expedition was the victory of Maida

[3] Charles Lefebure, 2nd-Lieut., 25.9.1793. Major, 8.3.1810. *War Services:* Holland, 1793–4; Trinidad, 1797; Porto Rico, 1797; Sicily, 1805–7; Peninsula, 1808–9 and 1810. Killed by a round shot at Matagorda, near Cadiz, 22.4.1810.

[4] Charles William Pasley, K.C.B., F.R.S., D.C.L. 2nd-Lieut., R.A., 1.12.1797. 2nd-Lieut., R.E., 1.4.1798. General, 20.9.60 Died 19.4.1861. *War Services:* Sicily, 1806; Copenhagen, 1807; Peninsula, 1808–9; Walcheren, 1809. Severely wounded at capture of Flushing. The subject of this sketch.

[5] John Thomas Jones, Bart., K.C.B. 2nd-Lieut., 30.8.1798. Maj.-Gen., 10.1.37. Died 26.2.1843. *War Services:* Sicily, 1805–6; Peninsula, 1808–9; Walcheren, 1809; Peninsula, 1810–13; Netherlands and France, 1815–16. Severely wounded at Burgos, 1813.

[6] George Griffith Lewis, C.B. 2nd-Lieut., 15.3.1803. Lieut.-Gen., 12.8.58. Died 24.10.1859. *War Services:* Sicily, 1805–11; Peninsula, 1813; France, 1817. Lost a leg at San Sebastian, 1813.

[7] William Nicholas, 2nd-Lieut., 21.12.1801. Bt. Major (posthumous), 27.4.12. *War Services:* Sicily, 1805–7; Egypt, 1807; Sicily, 1807–9; Peninsula, 1810–12. Died at Badajoz 14.4.1812, of wounds received on April 6th.

[8] George Francis Macleod, C.B. Lieut., 1.7.1801. Bt. Lieut.-Col., 21.6.17. Lieut.-Col., 23.3.25. Died 26.7.51. *War Services:* Sicily, 1806–9; Walcheren, 1809; Peninsula, 1811–12; Holland, 1815. Severely wounded, Badajoz, 1812.

[9] George Charles Hoste, Kt., C.B. 2nd-Lieut., 20.12.1802. Bt. Major, 17.3.14. Colonel, 23.11.41. Died 21.4.1845. *War Services:* Sicily, 1805–7; Egypt, 1807; Sicily, 1807–11; Holland, 1813–15; (Waterloo) France, 1815–16.

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on July 4th, when the French were completely routed. In those days, there was little for the Engineer officer to do professionally on the field of battle, and he often acted as staff officer, or galloper, or extra A.D.C. to the general. There is no record of any particular part played by Pasley on this day, but he was much impressed with the quality of our troops.

1807 After the battle of Maida, Pasley returned to England. In July, 1807, a Baltic Expedition set sail to seize the Danish capital and fleet at Copenhagen. Pasley sailed as the only engineer with Lord Cathcart on the preliminary expedition, and thus commented on the project :—" The enterprise of forcing the Danes—a nation of centuries !—to give up their fleet and capital, by an army which they can match in numbers, is of the most hazardous nature, particularly as Copenhagen is a fortified place." The expedition was successful, and Pasley described his own experiences to Burgoyne as follows :—" Amongst the Engineers we had a great deal to do and went through much fatigue. I was at one time 28 hours without sleep, but his Lordship in his dispatches was certainly fully as complimentary to us or more so, than we deserved. This service has pleased me very much with my profession, which in case of a siege is the most important branch by far of the military duty, and government has established a good precedent in their liberality to the Ordnance Corps, General Blomfield, the Commandant of Artillery, has been made a baronet, and Colonel D'Arcy,[2] the Commanding Engineer, has a pension of 24 shillings per diem for life. This is noble encouragement for the young enterprising officers, and times must go very hard with me if I do not at some future period come in for the loaves and fishes, if they adhere to the rule, for I had long made up my mind to distinguish myself, if I can. And fortune has for the last two years favoured my views by bringing me into all the pleasant and all the successful service that the British Army has had. I have long given up the idea of making money, which I see in our line is quite impossible. But now they give us this opening—Death, or the Four and Twenty shillings shall be my motto, or the Baronetcy. . . . I saw that the best soldiers in the world are of no avail unless properly managed. I must admit that one masterly thing was done, when Sir Arthur Wellesley, with very inferior numbers, entirely routed the Danish militia, 8,000 strong, taking one quarter of them prisoners, and he is the man whom I should wish to see at the head of the first large British army that acts."

After being employed on the building of Martello towers on the east coast, he volunteered his services to the Spanish leaders in the
1808 Peninsula, who in 1808 had risen against Napoleon. He was ordered to Spain as C.R.E. to Sir David Baird, and was then attached to General Leith, who was on a mission with Spanish troops in the Asturias, to reconnoitre and report on the country. Lefebure,[3]

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Birch[18] and J. T. Jones[5] were also with the mission. Pasley found the Spaniards glad to welcome them and most solicitous for their safety. He relates how after Blake's total defeat by the French, he was sheltered by a broken band of worn-out Spanish soldiers, who undertook to follow his leadership if he would give them a day or two's rest first; and when he said he could not wait, he was conducted to safety past the French posts and over the mountains by the least weary of the band. With Blake's defeat, the British mission ended. On November 18th, 1808, he joined Sir David Baird's staff at Astorga, as extra A.D.C., and, on the 25th, owing to his knowledge of Spanish, Sir John Moore's in the same capacity. He combined his duties on the staff with those of an engineer throughout the retreat to and battle of Corunna. The efforts of the engineers to blow up the bridges during this retreat were only in one instance successful in effecting *complete* destruction. In many cases the bridges were destroyed sufficiently to delay the enemy for many hours, and in some cases days; that the work was not more successful was to be ascribed to the lack of practical training on the part of the engineer officers and to the scanty means they had for carrying out the work. His experience on this retreat fixed Pasley's resolves in two directions; his first resolve to fight for the proper training of the engineer troops, officers and men, culminated in the formation of the S.M.E. at Chatham; his second resolve, to attempt to rouse the nation from its inferiority complex *vis-à-vis* the French power on land, was fulfilled when he produced his *Essay on the Military Policy and Institutions of the British Empire*, a book to be described later, which had a great influence in shaping our national policy. At Maida, Pasley had seen at first hand the fighting qualities of the British troops, and now he recorded his impressions of this retreat of 250 miles in these words:—"The only satisfaction derived is to know the infinite superiority of our soldiers to those of the rest of the world. Braver men never existed. In every attack, the enemy were baffled or beat off. They never could make the smallest impression upon our troops, nor did they ever occasion the least terror or confusion." Pasley was present when Sir John Moore died, and he returned home from Corunna with the rest of the Force. He left Lefebure[3] and Birch[18] behind, both wounded and in hospital, having devoted himself to nursing them so far as his duties would permit.

His next service was with the expedition to Holland under the Earl of Chatham,[19] which sailed in July, 1809. Pasley expressed a hope that the leader might inherit something of his father's spirit and not prove "one of those retreating and re-embarking generals, who had succeeded to the Marlboroughs and Peterboroughs of former times." Affairs were not, however, to prove to his liking, and a month later he expressed himself in vigorous terms to his friend Squire.[14] As might be expected with a man of his character, Pasley 1809

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could express himself forcibly when faced with incompetence or any suspicion of someone letting the Corps down, though with a prodigality of commas, when he had had time to think, that makes his sentences read in a rather disjointed manner. However, this letter runs all right :—" I this day* landed your horse and sent him by your servant. I only landed yesterday morning, and saw our works before Flushing. In six days, since the trenches were opened, we have only made one 6-gun and one 6-mortar battery, with a parcel of infernal in-and-outs from 800 to 1,000 yards from the place. Little Coote's wing was to do it all, so D'Arcy[2] was the man, but now Fyers[10] has begun since last night. The Corps of Engineers is disgraced and d—— for ever. The cry of the whole army and navy is against us. I found Jones[5] when I landed in a state of deep *despair*. Boteler[11] wished that the first shot might take off his head. The French are making counterworks, and do them faster than ours. We were offered the *whole* army to act under us. The Staff Corps, everything at our disposal. Such means, such power, such circumstances would have put life into a statue, by heavens it would have called a dead body from the grave, but what could we do with a parcel of old women at our head, with fellows without souls, to direct the operations of armies, with fellows old in years, poor in spirit, beardless in military experience, destitute of knowledge, not merely blockheads but blockbodies. I have not seen Birch[18] yet, but I am sorry to say he and Jones[5] are at daggers drawn. Colonel Douglas told me that he sincerely pitied us all. General Brownrigg says that the engineers are not fit to be employed in war. We want not their pity, and are more fit to be employed in war than them. I have formed my plans. I shall see the Captains (Rudyerd[12] excepted who is a married man). If they choose they will sign with me a protest against the operations. If not I shall write one myself, and neither earth, heaven nor hell shall alter my resolution."

With the arrival of Colonel Fyers[10] to take over charge, matters improved: Birch[18] was in charge of the right attack and Pasley was put in charge of the left. He proposed to move forward at once and intrench, and his plans were approved with modifications. But on the night of the 14th, it was discovered that the French garrison were cutting the eastern dyke to let in the sea. This would have made the position of the attackers, which was already sufficiently difficult owing to the water, an impossible one,

* 3. 7. 1809.

[10] William Fyers. 2nd-Lieut., 11.11.1773. Lt.-Gen., 12.8.19. Died 27.10.1829. *War Services:* America, 1775–83; Walcheren, 1809.

[11] Richard Boteler. 2nd-Lieut., 1.1.1804. Lt.-Col., 29.10.1828. Perished in the wreck* of the *Calypso*, February, 1833. *War Services:* Buenos Ayres, 1807; Peninsula, 1808–9; Walcheren, 1809; Peninsula, 1811–14.

[12] Charles William Rudyerd. 2nd-Lieut., R.A., 23.1.1793. 2nd-Lieut., R.E., 14.6.93. Died 19.10.1813. *War Services:* Holland, 1793–5; Holland, 1799; Walcheren, 1809.

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and a force under Colonel Pack was sent out at once to stop them. Pasley led the storming party of 100 men, which was successful at the expense of 5 officers and 30 men killed and wounded. Amongst the wounded was Pasley, who received a bayonet thrust in the thigh and a shot through the body. Mulcaster,[18] writing to Burgoyne[1] on September 12th, 1809, from Badajoz, thus described the affair. After telling of the receipt of the news of the capture of Flushing he said, "Our poor friend Pasley is badly wounded. He is, however, doing well. He had a musket ball through his body, and a bayonet stab in the thigh. He was wounded leading the storming party which carried one of the advanced works under Colonel Pack. He struck one Frenchman, disarmed a second, stabbed a third and was attacking a fourth when he fell. What a desperate dog!"

Pasley himself gave a less picturesque account of the affair, but stated how he scarcely felt the wounds at the time and was able to walk, apparently unattended, to the rear. As a matter of fact the shot through the body had injured his spine, he was laid up for months, and his recovery was despaired of. Burgoyne[1] wrote to him from Vizau in March, 1810, saying:—"I was much concerned 1810
to hear of your accident at Flushing, but would not write till I could congratulate you upon your entire recovery, which I understand now there is no doubt of. I do it therefore now with heart and soul. What will be your motto now? 'Death or a pension' is over, the first you have narrowly escaped, the other I presume you have got. I shall expect you soon to adopt Lord Nelson's 'Westminster Abbey or Dignities.'"

Owing to the effects of his wounds, Pasley's chances of further service in the field were over when he was only 28 years of age, and it is necessary to turn back somewhat to pick up the threads which will show what it was which led to the extraordinary success of his later life. Something of the part played by the junior officers of the Corps in the early years of the eighteen hundreds must now be made clear. The Corps contained at that time in its junior ranks a body of young men who in their professional zeal, and the keenness of their anxiety for the national glory and personal distinction have seldom been surpassed. Pasley writing at a later time thus described his contemporaries:—"The very inefficient state of the Engineer Department, strange to say, appeared to be unknown, not only to the rest of the Army, from the Commander-in-Chief to the youngest ensign, but even to the senior officers of the Engineers themselves, though several of them had served in the American War, of whom

[18] James Moncrief. Ensign, 28.1.1762. Colonel, 18.11.90. *War Services:* Havanah, 1762; America, 1776–80; Holland, 1793. Killed at the Battle of Hondschoote near Dunkirk, 7.9.1793.

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Colonel Moncrief,[13] the most distinguished, fell at Dunkirk. But it had been deeply felt and lamented by those officers who had commenced their military career in the first war with the French republic in 1793, and had afterwards served in Egypt, and on other expeditions terminating in a less satisfactory manner. Young or in the prime of manhood, full of enterprise and zeal, meeting and comparing notes together in the metropolis after the desultory expeditions in which they had served, and afterwards those employed in 1810 in the construction of the lines of Torres Vedras, meeting from time to time in some central spot, they excited each other and inspired their juniors with an *esprit-de-corps* and a devotion to the service of their Sovereign and Country that I do not suppose were ever exceeded. Captain Charles Lefebure,[3] who had served in the West Indies and in Holland and had been Commanding Engineer under Sir John Stuart in Calabria (afterwards unfortunately killed at Matagorda near Cadiz), was at first the most influential of these officers, partly from his character and example, being one of the most high-minded and disinterested men I have ever met with. He it was who first pointed out to me and other officers his juniors as early as 1805, the inefficiency of the Corps for want of disciplined and instructed Sappers and Miners. Of those employed in the Spanish Peninsula some years later, my intimate friend Captain John Squire[14] a man of superior literary, classical, as well as professional attainments, contributed most to keep up this noble spirit, and it was gratifying to me, on our meeting from time to time, after having been separated on different expeditions, and in corresponding with him, to find that our opinions on the state of the Corps and on the management of the war, for which he invariably advocated the most vigorous measures, always agreed." Burgoyne,[1] writing from Vizau in April, 1810, said :—" I am entirely on your side respecting the Corps and in everything else, and feel assured we want a great deal more than I will explain to you by letter. I had been brooding over these ideas for some time myself, but meeting nobody to encourage me, or to whom I dare broach my opinions, I could scarce believe I was myself sincere in them. Yours and Squire's[14] letters have given me confidence in these ideas and made me fit for anything. I have written to sound Mulcaster[15] and wait with impatience for his answer. I long to gain him, knowing him to be a clever fellow, and what is more, a smart, dashing, indefatigable officer."

Amongst the Burgoyne papers in the R.E. Museum is a letter from

[14] John Squire. 2nd-Lieut., R.A., 27.4.1793. 2nd-Lieut., R.E., 1.1.1797. Bt. Lieut.-Col., 27.4.12. *War Services:* Holland, 1799; Egypt, 1801; Buenos Ayres, 1806–8; Sweden, 1808; Peninsula, 1808–9; Walcheren, 1809; Peninsula, 1810–12. Died from fatigue, Truxillo, 19.5.1812.

[15] Edmund R. Mulcaster. 2nd-Lieut., 1.3.1804. 2nd-Capt., 24.6.09. *War Services:* Sicily, 1807–8; Peninsula, 1808–9 and 1809–12. Killed at 3rd siege of Badajoz, 25.3.1812.

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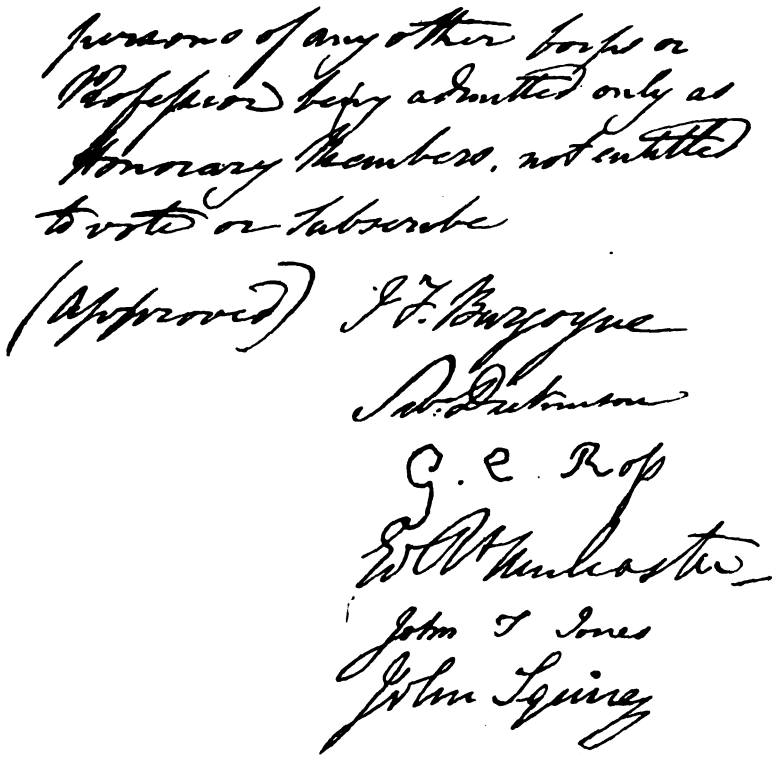
Mulcaster[15] to Burgoyne[1] (to "My dear Goss" from "your ever faithful friend, Mulco") which is dated January, 1810, and which shows that they had had under discussion for some time a project for forming amongst the officers of the Corps a "Society for procuring useful military information." This society actually took shape, and was confined to Captains and Field Officers of the Corps, the original members, all serving in the Peninsula at the time, being: Captains

SOCIETY FOR PROCURING USEFUL MILITARY INFORMATION.



FACSIMILE OF SIGNATURES ON ARTICLE OF ASSOCIATION

J. F. Burgoyne,[1] S. Dickenson,[16] G. C. Ross,[17] E. R. Mulcaster,[15] John T. Jones,[5] and John Squire.[14] In January, 1811, they agreed to elect to the society the following:—Birch,[18] Nicholas,[7] Goldfinch,[19]

[16] Sebastian Dickenson. 2nd-Lieut., 1.10.1804. 2nd-Capt., 29.5.10. *War Services:* Buenos Ayres, 1807; Walcheren, 1809; Peninsula, 1810–11. Killed at 1st siege of Badajoz, 11.5.1811.

[17] George Charles Ross. 2nd-Lieut., 1.7.1799. Capt., 24.6.09. *War Services:* Peninsula, 1809–12. Killed at Siege of Cuidad Rodrigo, 9.1.1812.

[18] John Francis Birch, C.B. 2nd-Lieut., R.A., 18.9.1793. 2nd-Lieut., R.E., 1.1.94. General, 20.6.54. Died 29.5.1856. *War Services:* Holland, 1793–5; Minorca, 1798; Egypt, 1801; Copenhagen, 1807; Peninsula, 1808–9; Walcheren, 1809; Peninsula, 1810–11.

[19] Henry Goldfinch, K.C.B. 2nd-Lieut., R.A., 1.3.1798. 2nd-Lieut., R.E., 24.6.98. Lt.-Gen., 11.11.51. Died 21.11.1854. *War Services:* Copenhagen, 1807; Peninsula, 1809–14.

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Fanshawe,[20] Pasley,[4] Boothby,[21] Thackeray,[22] Parker,[23] Lewis,[6] Marlow,[24] Douglas[25] and Arnold.[26] It seems likely that the exigencies of active service prevented this society from performing much useful work for its members; many were killed or wounded at the sieges of the next few years, but the mere fact of its formation bears testimony to the spirit which was alive amongst the less senior ranks of the Corps. It devolved upon two of the members to bear somewhat vehement testimony to the need for reform in the Corps; one, John T. Jones,[5] thereby fell into disfavour with the Right Honourable and Honourable Board, whilst the other, Charles Pasley, succeeded in carrying the reforms through.

As regards outside testimony to the spirit of the Corps at the time of the Peninsular War, Lord Wellington gave frequent praise in his dispatches to his Engineers both collectively and individually: in letters to General Murray and Lord Liverpool, however, after the capture of Badajoz in 1812 he was unfair and ungenerous as to their supposed lack of skill in their profession, knowing as he did, and no one better, the total lack of trained personnel there was with which to carry out siege works.* And after the Siege of San Sebastian, Lieut.-General Sir Lowry Cole wrote to Lieut.-Colonel Burgoyne, "I shall feel great pleasure at all times in doing justice to a corps

* Jones' Diary in R.E. Museum. "Saturday, 15th February. Lord Wellington this day held a meeting on the subject of the best attack of Badajoz. There were present General Castaños, Genl Girard—the Spanish Brigadier General of Engineers and Lt Colonel Fletcher. The Spaniards and His Lordship were for making the same attack as the French. Lt. Col F. proposed attacking the Bastion of Sn. Trinidad from the ground in front of the Picurina redoubt, but not being able to state his reasons, viz., the British Engineers not having establishment of either Sappers and [or] Miners and being therefore unequal to the task of contending with the mines of those fronts—no one of the Council would accede to his opinion—but Lord Wellington being reminded of our deficiencies agreed to the project saying he regretted extremely our deficiencies as it obliged him to undertake an attack he did not approve but that knowing our means he believed it to be the only attack in our power to get thro. What a reflexion on those who have governed the Engineer Service for the last nineteen years of war."

[20] Edward Fanshawe, C.B. Lieut., 1.7.1801. Lt.-Gen., 20.6.1854. Died 22.11.1858. *War Services:* Cape, 1805–6; Buenos Ayres, 1807; Peninsula, 1808–9; Walcheren, 1809.

[21] Charles Boothby. 2nd-Lieut., 1.1.1804. Capt., 21.7.13. Permanent Half-pay, 15.6.1815. Died in Holy Orders, 19.8.1846. *War Services:* Sicily, 1805–7; Sweden, 1808; Peninsula, 1808–9 and 1809–10. Lost his leg at battle of Talavera, 1809.

[22] Frederick Rennell Thackeray, C.B. 2nd-Lieut., R.A., 18.9.1793. 2nd-Lieut., R.E., 1.1.1794. General, 20.6.54. Died 19.9.1860. *War Services:* Surinam, 1799; St. Martin's and St. Bartholomew, 1801; Sicily, 1806–7; Egypt, 1807; Sicily, 1807–12; Peninsula, 1812–14.

[23] Edward Parker. 2nd-Lieut., 1.1.1804. Capt., 21.7.13. *War Service:* Egypt, 1807; Sicily, 1807–11; Peninsula, 1812–14. Killed at Orthes, 27.2.1814.

[24] Benjamin Marlow. 2nd-Lieut., R.A., 14.7.1798. 2nd-Lieut., R.E., 30.8.1798. Lt.-Col., 1.12.15. Died 11.10.1818. *War Services:* Copenhagen, 1807; America, 1812–14.

[25] William Douglas. 2nd-Lieut., 1.7.1801. General, 3.4.62. Died 10.2.1864. *War Services:* Sicily, 1809–12.

[26] James Robertson Arnold, K.H., K.C. 2nd-Lieut., R.A., 1.3.1798. 2nd-Lieut., R.E., 29.8.98. Lt.-Gen., 11.11.51. Died 27.12.1854. *War Services:* Malta, 1800; Egypt, 1801; Demarara, Essequibo, 1803; Surinam, 1804.

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throughout the younger branches of which there is a spirit that no other corps I know of possesses to the same degree."

It has been stated earlier that the battle of Maida impressed Pasley with the fighting qualities of the British troops, and it appears that from that time he formed the project of bringing before the British public the unsound principles on which our foreign policy was being conducted. He was convinced that if "Government would only give us an opportunity of making the experiment on a great scale, the British Troops would beat the revolutionary armies of France, as our forefathers had done those of Louis XIV." He planned to write an essay in two parts on the military policy and institutions of the British Empire, Part I of which was issued in 1810. The first two chapters had actually been written early in 1808, but active service prevented any further writing until the wounds received at Flushing put an end to his active service, and gave him enforced leisure. The first edition was issued in November, 1810, and the fourth edition was issued in the beginning of 1813, surely an unprecedented success for such a publication. Captain Jones,[5] writing from Wellington's H.Q. in March, 1811, said, "Lord Wellington reads it, Marshall Beresford reads it, in short it is universally read amongst us and as universally admired." It was received with an equal chorus of approval in the various papers of the time, *The Times* saying:—"The work has, we learn, excited greater attention among the higher classes of political readers in the country than any since the time of Mr. Burke." As will be explained later, the second part was never written, but the Fourth Edition was re-issued in 1857, and a fifth edition by Colonel B. R. Ward (R.E.) in 1914. The main theme of the essay was that we must act on land with our utmost vigour and smash Napoleon's power or be ourselves eventually smashed as soon as a period of peace had given Napoleon time, with the aid of all the countries which he had overrun and which were at his disposal for such assistance, to build up again his naval power: when, with all the odds against us, we must succumb to the whole power of the Continent. He especially decried our "evacuating policy," as he termed it, by which we landed forces in different parts, got the local people to implicate themselves with us, and then cleared off and left them to the mercy of our enemies. A bold policy, with Great Britain as a principal and not as an auxiliary, especially in Spain, was what he advocated. And whether it was due to his essay or not, that was the policy eventually adopted by us with success.

Such a notable public effort must undoubtedly have greatly strengthened Pasley's position in his efforts to get the needs of the Engineer Department attended to, and he was listened to by the Board of Ordnance with attention. He was not the only officer who had tried to move the I.G.F. to take some steps to get the necessity

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for the training of a body of sappers and miners recognized. Porter relates how Sir John Jones,[5] when Adjutant of the Royal Military Artificers at Woolwich after the Corunna campaign in 1809, repeatedly urged the advisability of giving the men a thorough training in field work and employing them with the army; but General Mann,[27] the Inspector-General of Fortifications, always met his proposals with the statement that "good workmen were like old gold, to be treasured up and not risked in the chances of war." Jones later on, in 1812, when writing to the I.G.F. on the same subject, went so far as to say that "Nero fiddled whilst Rome burned," an indiscretion, for which the writer received well-deserved censure.

Pasley himself, in writing to Colonel Fyers[10] at the Board of Ordnance on 12th May, 1809, gave his ideas on the subject of rendering the Corps of Royal Engineers more efficient, "which is now under agitation, and if agreeable to General Morse[28] and yourself, I am desirous of having this enclosure laid before the Master General of the Ordnance." Pasley's testimony has already been given above to the fact that "as early as 1805, the inefficiency of the Corps for want of disciplined and instructed sappers and miners" was a matter of discussion amongst the junior officers of the Corps, and it appears certain that the idea that a corps of sappers and miners was a necessity for work in the field had been simmering in the office of the Board for some time.* In 1809, Pasley wrote direct apparently to the M.G.O., Lord Chatham,[29] about the state of affairs at the Shop, and bet his commission he would make good his words! Lord Chatham ignored the wager, said he disagreed about the Shop, but was prepared to receive Pasley's statement; which was to the effect that during the peace after the American War, the education at Woolwich Academy had been "in so perfect a state as the military science of the time admitted, and the cadets never received their commissions without passing public examinations, of which the mathematical part was conducted by the Astronomer Royal and at which the Duke of Richmond,[30] the M.G.O., presided in person with laudable zeal. But on the increased demand for officers in consequence of the war with

* Papers have lately come to light in the Record Office which on further examination may show that between 1760 and 1770 a proposal to form a Corps of Sappers, Miners, Gabioniers, Pontoniers, etc., was put forward by a senior R.E. officer, complete with sketches for colours, uniform and equipment. It is probable that the raising of the R.M. Artificers to look after permanent fortifications blocked any scheme for field Engineer troops.

[27] Gother Mann. Ensign, 27.2.1763. General, 19.7.1821. Died 27.3.1830. *War Services:* Dominica, 1778; Holland, 1793–4. I.G.F., 1811–30.

[28] Robert Morse. Ensign, 8.2.1758. General, 25.4.1808. Died 28.1.1818. *War Services:* St. Malo, 1758; Martinique and Guadeloupe, 1759; Belleisle, 1761; Germany, 1762–3. I.G.F. 1802—11. "A good old fellow upon the whole, but no warrior."—*Pasley*.

[29] John, 2nd Earl of Chatham. Master General of the Ordnance, 1801–6 and 1807–10.

[30] Charles, 3rd Duke of Richmond, M.G.O., 1782–83 and 1784–95.

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the French Republic, the course had been cut short without being methodized, many important subjects having been omitted altogether and a smattering only of others taught."

During 1810, Pasley was on leave, recovering from his wounds, busy with the production of his *Essay on the Military Policy*, and thinking over the subject of the defects in the Corps. In 1811, things began to move: Pasley addressed Lord Mulgrave,[31] M.G.O., on the inefficient and dangerous state of the Department generally, "from which failures and disasters appeared to me to be inevitable in any siege the British Army might attempt, accompanied by the unmerited disgrace of the Corps to which I belonged—unmerited, because no corps can improve itself." Lord Mulgrave proved consistently sympathetic to Pasley's ideas, and further developments are thus described by Pasley himself at a later date. He had been posted to Plymouth in 1811, on recovering from his wounds sufficiently to resume duty, where he had found things pretty bad and had had to discharge "about 150 superannuated men (not old servants) and little helpless boys, who were put upon the works through charity." "I took the opportunity, whilst stationed at Plymouth in 1811, first as second and afterwards as Commanding Engineer *pro tempore*, to carry into effect, at my own expense, a system of practical and theoretical instruction for the junior officers of the Corps of Royal Engineers, and for the non-commissioned officers and privates of the Department, a Company of whom, then termed Royal Military Artificers, volunteered to work at the operations of a siege in the summer of that year, after their regular working hours for the day were over, and they were accordingly practised in the construction of a gun and mortar battery, and portions of parallels and approaches, after having previously made fascines and gabions from materials purchased in the neighbourhood." Pasley also attended schools to study the systems of Bell and Lancaster, and by the adoption of those systems worked out textbooks which enabled the volunteers of the R.M. Artificer Company who attended night-school, to teach each other. The men were rough and uneducated, and the instruction had to be of the simplest. 1810 1811

Pasley reported his success to Lord Mulgrave in December, 1811, and said he would not write the Part II* of his Essay, but would devote all his energies to improving the Department. He thus summarized what it had been his intention to write in this second part as far as the Engineer Department was concerned:—"In this work I should have suggested several improvements that appeared to me from my own experience and reflection to be essential, and more especially in

* Dealing with the Institutions of the British Empire.

[31] Henry, 1st Earl of Mulgrave, M.G.O., 1810–18.

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the important department in which I had the honour of serving, which was at that time so imperfectly organized that I considered the British Army, though admirably adapted for battle from the excellent discipline of the Cavalry, Artillery and Infantry and Riflemen or Light Troops, to be incapable of succeeding in a siege, though one of the most important operations of war, without either having recourse to the barbarous measure of incendiary bombardment, or without an enormous sacrifice of the lives of officers and soldiers in sanguinary assaults, which might be rendered unnecessary by a more efficient organization of the Royal Engineer Department, and especially by forming a well-instructed and well-disciplined body of Engineer soldiers, diligently exercised in all the operations of a siege, particularly in military mining and also in the formation of military bridges. The better instruction of the junior officers of the Royal Engineers appeared no less essential, for at that time they were not even taught the theory of the attack of fortresses at Woolwich Academy, where the course of instruction was very imperfect, and the examinations for commissions were merely a matter of form, and no genuine tests of proficiency. As for practical instruction, they had none, for they were sent on service without ever having seen a fascine or a gabion, without the smallest knowledge of the military passage of rivers, of military mining, or of any other operation of a siege, excepting what they might pick up from French writers, of which a striking proof occurred in Sir John Moore's retreat, when all attempts to blow up stone bridges to impede the progress of the enemy, made by officers of the Corps, myself amongst others, failed in effecting complete demolition, with the exception of one only, which Lieut. Davy,[32] a very promising young officer, succeeded in completely destroying, but at the expense of his own life, which he lost from not understanding the very simple precautions necessary to insure the safety of the person who fires the train of a mine. For my part, I should not even have known how to make a battery in the attack of Copenhagen, the first siege in which I was employed, but from the information I derived from a French book on the subject. Such were the ideas which I intended to submit to the public in 1809."

Lord Mulgrave[31] on receiving the letter reporting progress replied that he derived the greatest satisfaction from learning of Pasley's success, and he commended Pasley's decision not to publish to the world "the inefficiency of any Department for the improvement of which the cheerful co-operation of the chiefs and seniors is requisite. I am, however, persuaded that your own discretion has prevented any statement which could by its publication wound the feelings of higher ranks of the Branch of Service which your meritorious zeal is directed to improve to the utmost of your power."

[32] Henry Davy. 2nd-Lieut., 1.11.07. Lieut., 2.5.08. *War Services:* Peninsula, 1808–9. Killed at Betanzos on the retreat to Corunna, 10.1.1809.

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The Master General was not the only senior officer whom Pasley endeavoured to enlist on his side: he wrote also to the Duke of York, then Commander-in-Chief, and received a favourable reply. It appears from a letter to Burgoyne that he had addressed the Duke of Wellington also on the same subject. In the letter dated March 2nd, 1812, he says, "I think his Lordship rather used me ill. I sent him a present of my book, which as a Gentleman he ought to have acknowledged. At the same time I wrote to him a full account of the difficulties we laboured under owing to the want of men trained to the making of fascines, gabions, etc., and sapping. This letter, which was dated 27th July, 1811, he never thought proper to answer. I wrote him, because I thought Fletcher[33] would be too timid to say anything about the Department that would implicate Morse.[33]"

In February, 1812, on hearing from Colonel Rowley,[34] Deputy I.G.F., that General Mann[27] the I.G.F., wanted the training of the R.M. Artificers in fieldworks put in hand, Pasley came to London. A committee of Field Officers of the Corps, of which General Morse[28] was the President and Colonels Bridges,[35] Rowley [34] and Bryce[36] were members, assembled to give a report to Lord Mulgrave[31] on the subject. The report of this committee appeared on 14th March, and their recommendations may be summarized as follows:—(1) They considered the officers of the Corps of Engineers should also be the officers of the Military Artificers, although this was at variance with the usage of other countries. The men to be armed with brown carbines and bayonets. (2) Pasley's course and methods of instruction were approved. (3) Every officer of Engineers, whom circumstances would permit, should have the advantage of the Central School, and every officer in future, on his first appointment, should invariably be ordered on this duty. They concluded, "We are fully aware that to execute the difficult and extensive duties of Director of the School there must be united a portion of Science, experience, perseverance and temper which falls to the lot of few men. But, besides the zealous co-operation which we trust that he would find in all ranks—we have no doubt such encouragement will be afforded, by the M.G., as would give a stimulus to laudable ambition and authority to the Director." 1812

Thus was a blessing pronounced on a scheme for which the more

[33] Richard Fletcher, Bart., K.C.H. 2nd-Lieut., R.A., 9.7.1788. 2nd-Lieut., R.E., 29.6.90. Lieut.-Col., 24.6.09. *War Services:* Martinique, St. Lucia and Guadeloupe, 1794; St. Lucia, 1796; Syria, 1801; Egypt, 1801; Copenhagen, 1807; Peninsula, 1808–9 and 1809–13. Killed at storming of San Sebastian, 31.8.1813.

[34] John Rowley. 2nd-Lieut., R.A., 23.6.1786. 2nd-Lieut., R.E., 23.8.87. Maj.-Gen., 19.7.1821. Died 1.12.1824. *War Services:* Holland, 1793–5.

[35] George Bridges. 2nd-Lieut., R.A., 1.4.1776. 2nd-Lieut., R.E., 12.12.1776. Maj.-Gen., 12.8.1819. Died 1.6.1825. *War Services:* Cape, 1795.

[36] Alexander Bryce, Kt., C.B., K.C.H. 2nd-Lieut., R.A., 24.8.1787. 2nd-Lieut., R.E., 12.3.1789. Maj.-Gen., 27.5.25. Died 4.10.1832. *War Services:* Egypt, 1801; Sicily, 1807–11; Netherlands and France, 1815–16.

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junior members of the Corps had been pressing for so many years against the opposition of Headquarters and the Board of Ordnance.

Lord Mulgrave[31] had expressed the desire that Pasley should be the first Director, but a difficulty meantime had arisen which threatened to wreck this part of the scheme. In February, Pasley had presented a memorial to Lord Mulgrave, asking for his recommendation for promotion to the rank of Brevet Major. The grant of brevet rank to officers of the Ordnance Corps, where promotion was strictly by seniority, had only recently been obtained, and Pasley found that his juniors (Burgoyne, Nicholas, Macleod, J. T. Jones) were getting brevets for services in the Peninsula, whilst he held that his wounds and other services were no less meritorious. To his surprise, though his claims were backed by the I.G.F., Lord Mulgrave refused to recommend him. Two grounds were adduced for his refusal, first, that the contemplated work of training was not of such importance as to justify the recommendation, and secondly the war service, though admitted to be most meritorious and worthy of recognition, had been performed under *a different Administration!* Lord Mulgrave was adamant about the recommendation, and Pasley was equally determined that without the brevet rank he would not accept the Directorship, and it is necessary to turn to the Peninsula to see how the deadlock came to an end.

In the *Journal of Sieges in Spain*, second edition, the author states that " on the failure of the attack of Badajoz, in 1811, the most pressing applications were made, that half a dozen companies might be selected from the Royal Military Artificers to be formed into a body under the name of Royal Sappers and Miners, that officers should be permanently attached to the companies so selected, and after some instruction in their art, the six companies should be sent out to aid the troops in their future siege operations."* The application was repeated after the capture of Ciudad Rodrigo, which took place on January 20th, 1812.

In the Diary of Major J. T. Jones,[5] Brigade-Major to Sir Richard Fletcher,[33] is an entry dated 29th January, 1812, which starts:— " A Journal of the Siege and a plan of the attack (of Ciudad Rodrigo) was sent by the mail of this day to Lord Mulgrave and to Lieut.-General Mann.[28] Col. Fletcher made a representation to the Inspector-General of Fortifications of the necessity of a corps of Sappers and Miners to be immediately formed and sent to this country." (See Appendix I.) Next, Lord Wellington sent a dispatch to the Earl of Liverpool, dated 11th February, 1812, in which

* It would appear that the author's recollection of the exact details of the proposals are at fault. This second edition, which varies considerably from the first published in 1814, came out in 1827. The details given above are practically the same as those given in Appendix I, dated January 29th, 1812, whilst the *Journals* state " This application was repeated in the most forcible manner *previously to* the siege of Ciudad Rodrigo." This should apparently be " *after* the siege."

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he said, " I would beg to suggest to your Lordship the expediency of adding to the Engineers' establishment a corps of sappers and miners. It is inconceivable with what disadvantage we undertake anything like a siege for want of assistance of this description. There is no French *corps d'armée* which has not a battalion of sappers and a company of miners. But we are obliged to depend for assistance of this description upon the regiments of the line ; and although the men are brave and willing, they want the knowledge and training which are necessary. Many casualties among them consequently occur, and much valuable time is lost at the most critical period of the siege." Then followed the third siege and capture of Badajoz, when the losses in the assault of the breaches were dreadful, and casualties amongst the nineteen officers of engineers employed at the siege amounted to four killed and nine wounded. Of these, the casualties amongst the engineer officers who conducted the different columns to the assault were two killed, one mortally wounded, and two severely wounded. After the capture, Wellington sent through Lieut.-Colonel Torrens, Military Secretary to H.R.H. the C.-in-C., a letter to the Earl of Liverpool, strongly urging the formation of a corps of trained sappers and miners. This letter, which is given in full in Appendix II, was misplaced* and lay forgotten amongst a bundle of unimportant papers for 57 years. It was first printed in the *Athenæum* of the last week of April, 1889, and was reprinted in the *R.E. Journal* of June, 1889. The letter is headed " Camp at Badajoz, April 7, 1812," and arrived in England whilst there was the deadlock between Lord Mulgrave and Pasley over the grant of brevet rank and the appointment as Director of the new School. The effect of the letter was immediate ; Pasley became a Brevet-Major and Director of the School by the end of that same month !

(*To be continued.*)

* See note in Vol. IX of Wellington's *Dispatches*.

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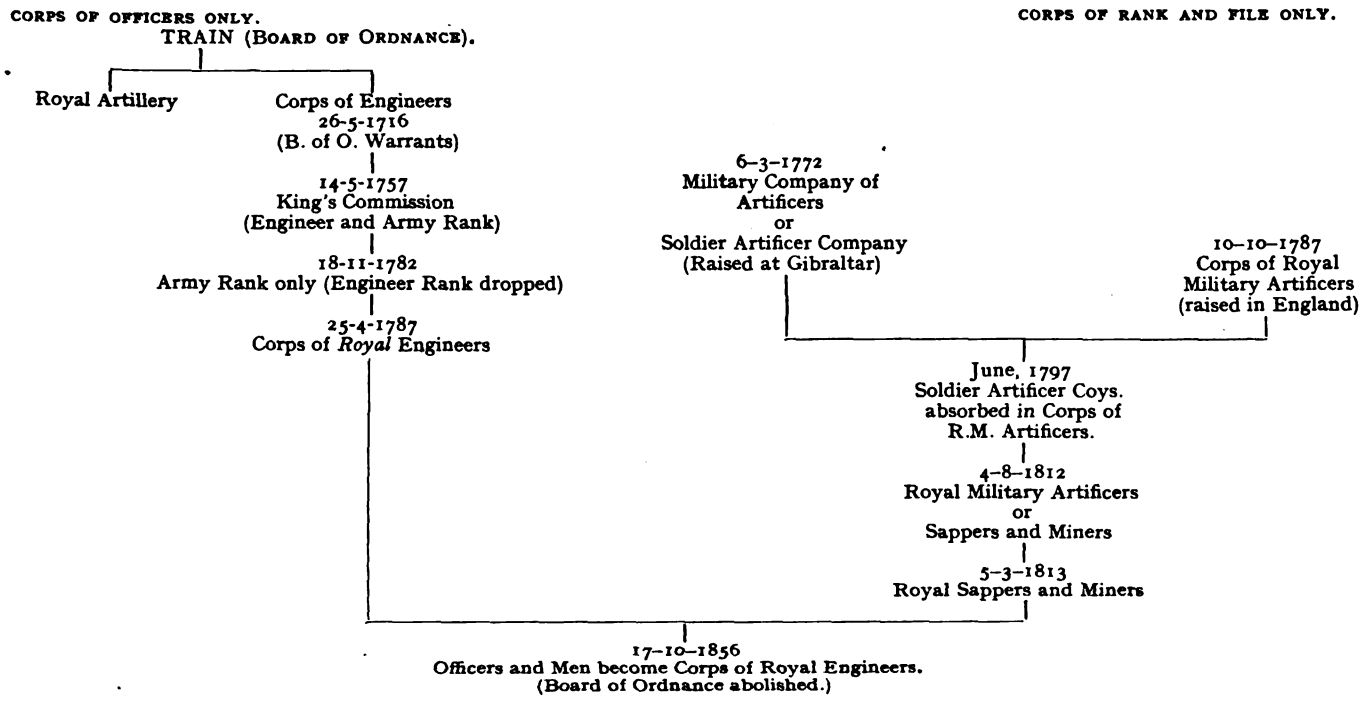

CHART SHOWING THE DEVELOPMENT OF THE CORPS OF ROYAL ENGINEERS.

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APPENDIX I.

(Extract from the diary of Major J. T. Jones, R.E., Brigade-Major to Sir Richard Fletcher, Commanding Engineer in the Peninsula.)

CIUDAD RODRIGO, JANUARY 29TH, 1812.

A Journal of the Siege and a plan of the attack was sent by the mail of this day to Lord Mulgrave and to Lt.-General Mann. Col. Fletcher made a representation to the Inspector-General of Fortifications of the necessity of a Corps of Sappers and Miners to be immediately formed and sent out to this Country.

Copy of a paper transmitted to Lt.-Col. Rowley.

Suggestions for the speedy formation of an efficient Corps of Sappers and Miners from the present Corps of R.M. Artificers.

1. Eight Hundred Rank and File, including Serjeants, to be selected from the Corps of R.M. Artificers—these men to be divided into ten companies of 80 men each, to be styled the Corps of Royal Sappers and Miners. The remaining — men to form as at present Companies of R.M. Artificers for garrison duty.

2. The uniform of the Corps of Sappers and Miners and of the Companies of Artificers for garrison duty to be red.

3. The ten Companies of Royal Sappers and Miners to be officered by the ten junior second Captains, the ten junior first Lieutenants and the ten senior second Lieutenants of the Corps of Royal Engineers.

These officers for the time being to be considered actually and *bona fide* officers of Sappers and Miners, performing every kind of regimental duty and wearing the same uniform as the men.

The other officers of the Corps of Royal Engineers to wear a blue uniform as at present and to be considered distinctly as having no charge of the above men, nor being liable to be called upon for the performance of any regimental duty whatever.

4. The Companies of Artificers for garrison duty to have officers of their own and which might be made a fine field of encouragement and promotion for the Serjeant-Majors of Sappers.

5. No Sub-Lieutenant to be attached to the Companies of Sappers and Miners, but three or four Serjeant-Majors to be allowed on the establishment of the Corps.

6. The officers, N.C. officers and privates of the Corps of Sappers and Miners to have a higher pay than the rest of the Army in like manner to the Staff Corps and in a similar way to be divided into Classes.

7. All men at first to be indiscriminately enlisted for the Corps of R.M. Artificers and then the proper subjects to be transferred to the Sappers and Miners—this measure will admit of any bad subjects or unfit men being returned to the Artificer Companies for garrison duty.

8. Intelligent men to be enlisted for the Corps of Sappers and Miners whether mechanics or not provided they can read and write and understand arithmetic.

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9. The men to be all thoroughly trained to the Sap—the Carpenters and Miners to the forming of galleries and mines and the whole to the tracing out of works, profiling, levelling, etc., etc.

10. Six Companies of the Corps of Sappers and Miners to be with the Army in the field in Portugal—two Companies with the Army in the Mediterranean and the other two at the Head Quarters of the Corps in training as a depot from which to keep up the effective force of the Companies in the field and in readiness to accompany any small expedition which may leave England.

The following advantages of the above plan were pointed out in an accompanying letter :—

1. By officering the Companies of Sappers and Miners from the Corps of Engineers, all jealousies of rank and employment between the officers of Engineers and the officers of Sappers is avoided.

2. Every officer of Engineers in his turn has the opportunity to become acquainted with regimental duty and the care of troops, and the objection frequently urged against giving Engineers commands, that they know nothing of the discipline and manœuvring of troops, is done away.

3. The Corps of Engineers will imbibe a proper degree of military knowledge, at the same time that the senior officers are put on a footing with the Staff of the Army and will not be subject as at present to have their situations lowered by being made to perform regimental duty beneath the rank they hold in the service.*

4. The men of the Sappers and Miners will be properly looked after, which never can be the case whilst the officers have a superior duty to perform. The Engineer Officers commanding Companies of R.M. Artificers in this Country, from their professional avocations, seldom or never see their men.

5. Under this establishment the Corps can never become a burden on this Country—as when there are no armies in the Field the men can be employed on the permanent works going forward in England and the officers can act as Engineers.

6. By the Companies being commanded by the junior second Captains —the Commanding Engineer must invariably be senior to the officers of Sappers and Miners and will have the direction of the Corps, as the Qr. Mr. General of an Army has the direction of the Staff Corps, but the discipline of the Sappers must rest with the senior officer of Sappers.

APPENDIX II.

Letter from the Duke of Wellington to the Earl of Liverpool :—

Camp at Badajoz, April 7, 1812.

My Dear Lord,—My dispatches of this date will convey the account of the capture of Badajoz, which affords as strong an instance of the gallantry of our troops as has ever been displayed. But I anxiously

* Sir Chas. Shipley as a Lieut.-Colonel was obliged by Lieut.-General Grinfield to fall in and do duty with a single company of R.M. Artificers—a degradation which could not have occurred to a Lieut.-Colonel in the line.

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hope I shall never again be the instrument of putting them to such a test as that to which they were put last night. I assure your Lordship that it is quite impossible to expect to carry fortified places by *vive force* without incurring great loss and being exposed to the chance of failure, unless the army should be provided with a regular trained corps of sappers and miners. I never yet knew a head of a military establishment or of an army undertaking a siege without the aid of such a corps, excepting the British Army. There is a body of sappers and miners attached to every French corps and each of the armies in the East Indies has one: and every army in the world except ourselves. The consequence of being so unprovided with the people necessary to approach a regularly fortified place are—first, that our engineers although well educated and brave, have never turned their minds to the mode of conducting a regular siege, as it is useless to think of that which it is impossible in our service to perform. They think they have done their duty when they construct a battery, with a secure communication to it, which can make a breach in the wall of a place; and, secondly, these breaches are to be carried by *vive force* by an infinite sacrifice of officers and soldiers. To this add that storming a breach, or attacking a place by escalade, is an operation of a very different description from fighting a general action. In the latter every man, generally speaking, has an equal chance; but in the former the officers, the bravest and best of the non-commissioned officers and soldiers, go first. The loss falls upon these; and five minutes after the breach is carried women and children might enter it instead of men. You see in the attack of Badajoz we had six out of seven general officers employed, all their staff, and a very large proportion of the officers killed or wounded. In the attack of the Picurina it was the same, and we lost 200 out of 500 men employed. These great losses would be avoided, and, in my opinion time gained in every siege, if we had the properly-trained people to carry it on. I declare I have never seen these breaches more practicable in themselves than the three in the walls of Badajoz; and the fort must have surrendered with these breaches open if I had been able to approach the place. But when I had made the third breach on the evening of the 6th, I could do no more. I was obliged then to storm or give the business up, and when I ordered the assault I was certain I should lose our best officers and men. It is a cruel situation for any person to be placed in, and I earnestly recommend to your lordship to have a corps of sappers and miners formed without loss of time.

Believe me, my dear lord,
Ever yours most sincerely,
WELLINGTON.

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MAINTENANCE OF LANDING GROUNDS.

A Lecture delivered at the S.M.E., Chatham, on October 9th, 1930, by H. A. LEWIS-DALE, Esq., M.INST.C.E., M.I.MECH.E., *Assistant-Director of Works, Air Ministry.*

I HAVE been asked to lecture to you on this subject, because, under certain circumstances, the Royal Engineers will be responsible for works services in connection with aerodromes. My remarks this afternoon will be directed more particularly to that essential and vital part of an aerodrome—the landing ground.

Although the actual landing ground constitutes but a part of the Engineer's responsibility, it is undoubtedly the most vital point of that responsibility from the pilot's point of view. Bad and neglected landing grounds have their corollary in an abnormal number of crashes, endangering life and limb and causing the loss of many thousands of pounds in the value of machines and resulting generally in impaired efficiency of operations.

The problems connected with hangars and other technical buildings and the regimental accommodation—important as they are—are similar in character to works which you are normally called upon to deal with, but the formation and the maintenance of landing grounds involve problems of a special nature, which are exercising not only the Air Ministry Engineering Staff and municipal authorities in this country, but similar authorities overseas.

These landing ground problems are not, of course, new, but have become more pressing and urgent during recent years for at least three reasons :—

(*a*) The rapidly increasing size and weight of aeroplanes.
(*b*) The more intensive uses to which a landing ground is subjected.
(*c*) Landing grounds have in many cases steadily deteriorated due to past neglect, and lack of foresight as to the factors (*a*) and (*b*).

SELECTION OF SITES.

Before going on to discuss the special problems of maintaining a satisfactory surface, it is worth while to mention briefly some of the factors which should be taken into consideration when selecting a site, as it is obvious that the final choice of a site has a considerable

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bearing on the question not only of the first costs of construction, but also on the cost of subsequent maintenance.

Factors which influence the selection of a site (apart from purely military considerations) are :—

(i) Extent and nature of ground required.
(ii) Air approaches.
(iii) Meteorological conditions.
(iv) Building facilities.
(v) Rail and road facilities.
(vi) Water, power and lighting supplies.
(vii) Facilities for drainage.

I propose to pass somewhat quickly over headings (i) to (vi), and to concentrate during the time at my disposal more particularly on the all-important question of drainage, and on the methods to be adopted to obtain and to maintain an efficient landing surface under all conditions of weather and user.

(*i*) *Extent and Nature of Ground.*

An approximately level area is required not less than 600 yards in all directions, and preferably 1,000 yards. An unobstructed area of this size is seldom found ready-made in England or thickly-populated centres, and the removal of hedges, trees and other obstructions, and the piping and filling in of ditches and grading of surface are usually involved. High-lying ground is generally preferable as ensuring more freedom from fog and from drainage difficulties : ground surrounded by hills which cause dangerous air currents is to be avoided.

Land laid in permanent pasture, free from sharp changes of inclination and without ridges and furrows, is most suitable.

Gradients in excess of about 1 in 40 are undesirable. The surface and sub-soil should be of a porous nature, sufficiently solid to take the impact and weight of large aeroplanes. A good rough test of a ground is to drive a fully-laden 3-ton pneumatic-tyred lorry slowly across it, and if the wheels do not sink in, the ground is likely under ordinary circumstances to be a good one. In this connection, however, it should be noted that soggy ground can often be improved if time permits by suitable drainage work.

The following description of how an apparently most unlikely site is now being developed as a landing ground overseas may be of interest. (Figs. 1 and 2.)

When originally surveyed in 1926, the ground was covered with scrub and patches of trees and was practically a flat swamp, subject to periodical flooding during high spring tides. The sub-soil, to a depth of 6 ft. and probably much deeper, consisted of blue clay, soft enough for a walking-stick to penetrate several feet into the ground.

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There was, however, no alternative to this site within a radius of many miles, except certain uneven rubber and mining areas, which would have been most expensive to acquire and which failed in many ways to fulfil the conditions necessary for a satisfactory landing ground.

Unlikely though the above-mentioned site appeared, expert opinion was held that, after necessary engineering works had been carried out, a reasonably good landing ground would be obtained. This

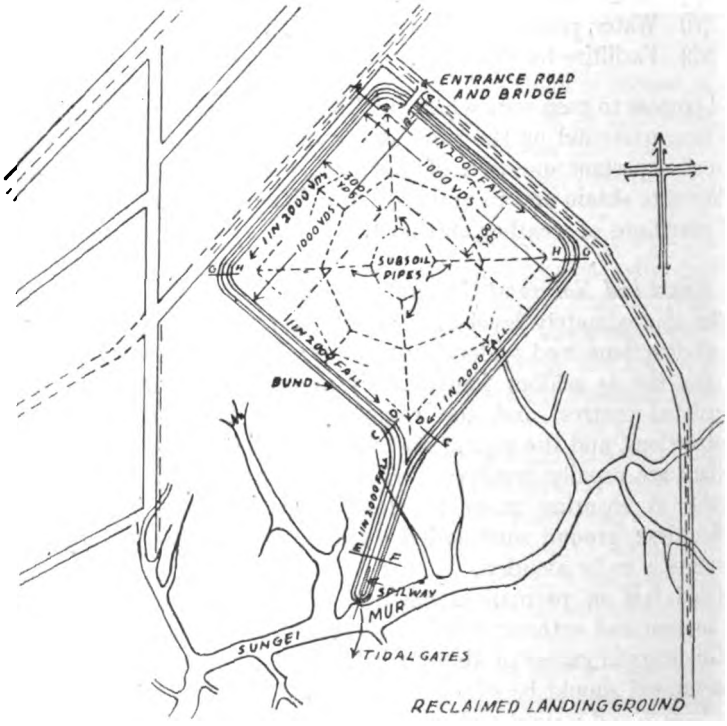

FIG. 1.

expert opinion was reinforced by the fact that a smaller but similar area hard by had been reclaimed and protected from tidal action and was actually in use as a recreation ground. An experiment was made of driving a 3-ton lorry over this ground after heavy rain—a fairly good test to which the surface stood up remarkably well.

Briefly, the engineering work which is being carried out is as follows :—

(*a*) The enclosing of the site by a bund to exclude tidal water.

(*b*) The formation of a ditch inside and parallel to the bund to collect and retain rainfall, with tidal sluice into adjacent river.

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(*c*) The clearing and grading of the site, and laying of sub-soil drainage pipes.

(*d*) The formation of an L-shaped level area, which will be extended later as funds permit. If found necessary, this will be slightly "domed" to give rain-water a natural run-off, but this was not done in the case of the recreation ground referred to.

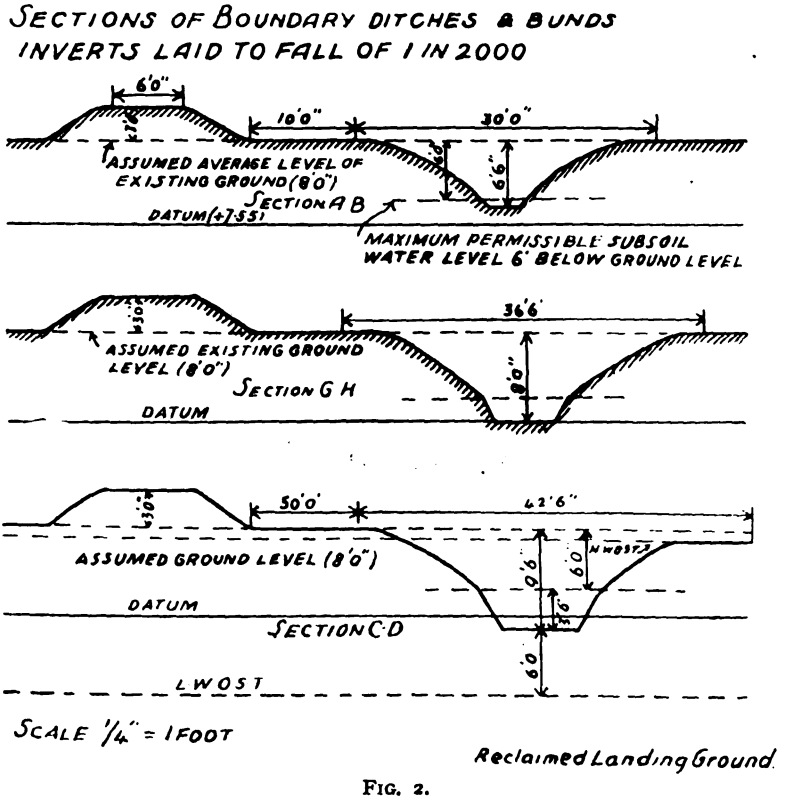

FIG. 2.

(*ii*) *Air Approaches.*

Permanent obstructions of the nature of church spires, high buildings and tall factory chimneys, may rule out the selection of a site admirable in other respects. Such obstructions as trees, hedges, telegraph poles, etc., are not insuperable as they can be removed if necessary.

(*iii*) *Local Meteorological Conditions.*

The liability of a district to rainfall, flood, fog, mist, high wind, squalls, which in excess are adverse factors in choosing a site, must be studied.

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(*iv*), (*v*), (*vi*).

The importance of adequate ***building facilities, rail, road and water communication, water, electric light and power supplies, etc.***, where a permanent aerodrome is concerned, is so obvious as merely to require mention here, but this summary of the factors necessary to be taken into consideration when selecting a site would be incomplete without a reference to them.

LANDING GROUND.

In constructing a new aerodrome, the landing ground, with its drainage and surface problems, should be tackled immediately the site is acquired, and all the time which is necessarily occupied by the erection of either temporary or permanent hangars and other accommodation should be utilized in getting the landing ground into good condition.

This time may be a longer or shorter period, depending upon military necessity, but even a few weeks of concentrated effort can work wonders in improving landing conditions.

It may here be stated that the formation of the leading edge of concrete or other hard aprons in front of the sheds should be done at the outset, so that work carried out on the landing surface shall not subsequently be disturbed by excavations. All traffic in connection with building operations should be kept within this leading edge and off the landing ground.

DRAINAGE.

The drainage of a landing ground differs from other forms of drainage in that water from large surfaces has to be collected and disposed of outside the landing area, without resorting to open ditches and gutters. The natural conditions which go to make a good landing ground, viz., levelness of surface and freedom from obstruction, are those which often cause considerable difficulties in maintaining a dry and hard landing surface. The problem is further accentuated by the ground having to withstand a user which in its nature is constantly breaking up the surface, and tends to interfere with the under-drainage.

MAINTENANCE OF SURFACE.

The impact of an aeroplane, weighing several tons and landing at a speed of 60 miles per hour, braked by a tail-skid which is in the nature of a plough, all occurring over and over again in practically the same spot and in all weathers, are the conditions which have to be faced at the present time. The tail-skid in heavy planes will probably be abolished soon in favour of landing-wheel-brakes, but as

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things are at present this devastating ploughing action on the surface of the aerodrome has to be allowed for and made good as it occurs.

It will be helpful to consider the landing ground as consisting of three parts (Fig. 3) :—

(*a*) The area A occupied by the hangars and other buildings and aprons.

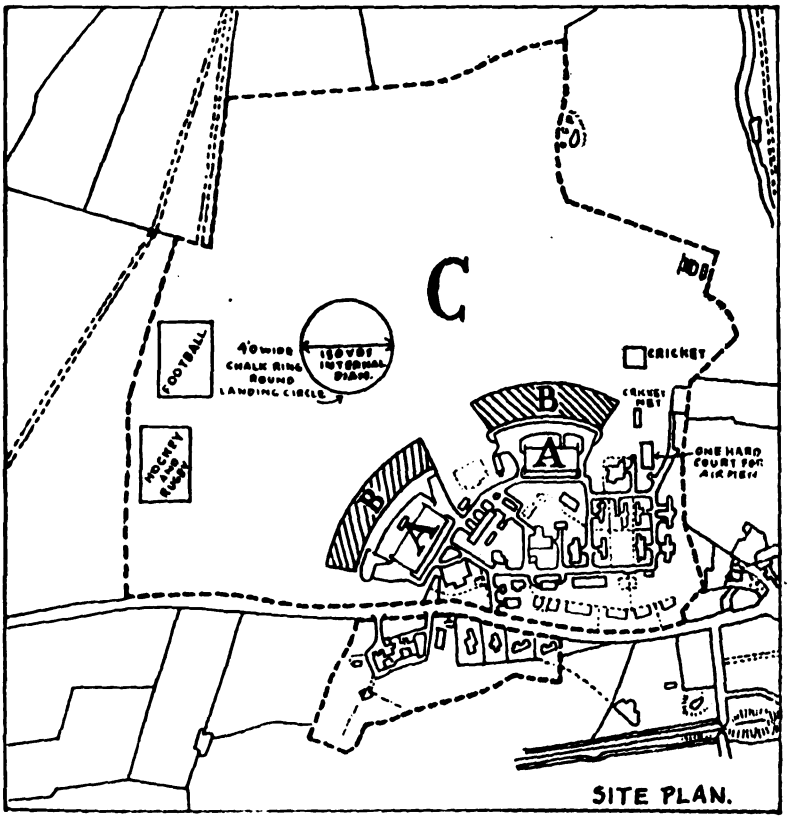

FIG. 3.

(*b*) The area B adjoining the aprons and extending, say, 50 to 100 yards outwards, on which traffic is very concentrated and where the starting and taxi-ing of machines take place.

(*c*) The rest of the landing ground which can be termed the " outfield," area C.

Area A.

The impervious area occupied by the roofs of hangars and hard surfaced aprons and roads is often as much as ten acres, one boundary of which abuts on to the landing ground at the very points where aeroplane traffic is most concentrated. It is, therefore, essential that water falling upon this area should be efficiently and quickly carried

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off. To ensure this, the aprons should be carefully graded during construction, gulleys and underground drains being provided to carry the water right away from the abutting surfaces already referred to. This, no doubt, seems obvious, but many cases have come to notice where a landing ground has suffered by water from these impervious surfaces being allowed to flow over the landing ground instead of being properly carried away.

Area B.

The area outside the apron and extending, say, 100 yards into the landing ground, is the most difficult part of the landing ground to deal with, in respect both of drainage and maintenance of surface. This is the area on which the traffic, both when taking off and when landing, is most concentrated, and where the damage caused to the surface from the action of tail-skids when the machine is taxi-ing is at a maximum. The constant churning up of the ground, unless specially treated as will be described later, generally results in a veritable quagmire when the weather is wet or a dust heap when the weather is dry, which is not only a danger to men and machines in landing, but also causes clods of mud and dirt to be carried into hangars and machines. A clod of dirt from the pilot's boots is a really potential source of danger among delicate controls.

In many cases, it is futile to attempt to maintain a grass surface under these conditions, and recognizing this, the Air Ministry has, during the past two years, conducted experiments on a large scale to arrive at a surface in front of the aprons which will provide a remedy, and to meet the following conditions :—

(*a*) Hard enough to take the weight of machines.
(*b*) Soft enough to allow the tail-skids to bite.
(*c*) Capable of quick and easy repair when scored by the tail-skids.
(*d*) Reasonably cheap in first cost and in maintenance.
(*e*) Capable of carrying off flood water quickly and effectively.
(*f*) Freedom from dust, non-sticking and non-skidding.

Obviously a mere extension of the concrete or tarmac apron is not a solution of this problem : first, the expense would be enormous, and secondly, machines cannot safely land upon so hard a surface. The result would be that once more the traffic would concentrate on the softer surface in front of the extension, with similar results to those already described.

The experience of the Air Ministry is that there is no cut-and-dried solution of this problem, owing to the widely differing nature of the soil and sub-soil of various localities. Each case has to be investigated and dealt with on its merits, but experiments have definitely established that it is possible in many cases to obtain a firm and dust-

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less surface by mixing oil of a suitable grade with the natural earth of the landing ground.

The first step in these experiments was to get the soil analysed. The Shell Mex Co., Ltd., were willing to undertake an analysis of any soil sent to them and by actual experiment in their laboratories to arrive at the most suitable grade of oil and the quantity of mixture per square yard for the particular ground it was desired to treat.

These laboratory experiments established that natural soil of a clayey nature incorporates extraordinarily well with road oils marketed by the Shell Mex Co., and large-scale experiments have been carried out at two aerodromes in accordance with the detailed specification given in Appendix A.

I would particularly draw attention to the clause in this specification dealing with the drainage of the treated area. Oiling the area, of course, makes it impervious to water, and it is essential to take such steps as will ensure storm water being quickly carried off the surface, and away in underground conduits from the adjacent grass surface. This can only be effected by means of French drains, cut after the oiling is completed, as described in the specification, the size and spacing thereof being dependent upon the natural fall of the ground. It is particularly important that an adequate French drain should be provided along the edge of the oiled surface which meets the grass surface of the landing ground.

Other points to emphasize are :—

(*a*) that thorough mixing of the oil and ground shall take place, otherwise pot holes and drag of surface will soon occur ;

(*b*) that the treatment is carried to a sufficient depth (depending upon the soil, but never less than 9 to 12 inches) to ensure tail-skids of machines not ploughing through the oiled surface ;

(*c*) that the correct grade of oil or bitumen emulsion is employed.

The cost of the above treatment, including drains, works out at about 2s. 4d. per yard super for an area of 12,000 square yards.

In a case where the surface consisted of stiff clay, a variation of the method outlined above was adopted. The whole site was excavated to a depth of 12 inches and burnt in heaps to hard ballast. After screening, the coarse material was returned to site, spread and rolled as foundation 9 inches thick, the remaining 3 inches of fine material being mixed with a bitumen emulsion (" Colas," in this case) spread and rolled to form a top impervious layer. The drainage was dealt with exactly as in the case of the oil and natural earth treatment, and the total cost was about 3s. 4d. per yard super for 12,000 square yards. Subsequent maintenance costs will be trifling.

A detailed specification of the burning and oiling process as applied to a particular case is given in Appendix B.

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So much for the question of the drainage and maintenance of the surfaces of the concrete or tarmac aprons, and the surfaces of the landing ground immediately adjacent thereto. The oiled treatment promises to be eminently successful in those cases where the ground is of a clayey nature, and for areas where there is heavy and concentrated traffic and much taxi-ing. The ruts made by the skids can easily be rolled out and levelled, as they are more or less clean cuts, as opposed to the complete uprooting of the turf on a grass surface, and after the first oiling, maintenance is reduced to a minimum. On the other hand, any attempt to maintain a grass surface by returfing, or by ploughing up and sowing, means putting that section of the ground out of action for months, and in the end only provides a surface which is subject to precisely the same troublous conditions within a short period of use.

I am not claiming that the oiled treatment is universally necessary, or practicable. The Air Ministry has not succeeded in finding an emulsion which is entirely suitable for very light and sandy soil, but experiments in this direction are being proceeded with. We learn from an American publication called *Airports*, dated June, 1930, that a solid and compact ground has been obtained by mixing sandy soil with steam-distilled Mexican petroleum and asphalt of a suitable specification. Light soils, however, generally have good natural drainage, and even where grass cannot be successfully grown, they can often be kept in reasonable condition by watering and rolling. But oiling is probably the most practicable solution for dealing with that portion of the landing ground adjacent to the aprons in the heavier clayey type of ground I have previously described, and in America many hundreds of acres have been dealt with in a similar manner.

The method can be successfully applied to a light soil by importing a quantity of clayey material to the ground and incorporating it with the natural soil and oil. This, of course, adds to the cost, but it has been successfully done in America, and failing other means of making a satisfactory and dustless surface is worthy of consideration.

Area C. "Outfield."

Then as regards the remainder of the landing surface, which I will call the "outfield." As conditions are at present, the majority of landing grounds in this country are grass. Abroad, they often consist of more or less compact sandy wastes.

It is an axiom that the ground must be properly drained, but any scheme proposed must be thoroughly thought out before it is embarked upon. A contoured plan is a necessity. On it should be indicated all existing drains, and actual observations of the conditions of the ground and outfalls after heavy rainfall should be made and noted on the plan. The route and sizes of main lines of collecting

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drains can then be decided upon. Where they cross the landing ground they must be of French drain type.

It is important to reduce pipe feeder drains to a minimum, and with this in view it is a good plan first to open up the main collector trenches, taking great care with the grading, and then to leave them open until sufficient heavy rains have fallen to allow of reliable data as to their effect on surrounding surfaces being obtained.

Ground which is disturbed by removing the natural turf and by digging trenches for the purpose of laying agricultural pipes, sometimes takes years to consolidate, and the landing ground must be closed to aircraft all the time operations are in hand and during a period for recovery afterwards. Mole drainage often provides a most useful and efficient substitute, in suitable soils, for the pipe system —it is cheap, and can be done over again after a period of years.

Before cutting up the ground for feeder drains, the engineer should, therefore, be quite satisfied they are necessary. Many sub-soils will carry the water away into main collector drains without pipe draining, especially when there is a good natural fall of the ground. Heavy ground such as clay requires much more intensive drainage than sandy, loamy soils.

Ridges and furrows must be levelled out. If good turf exists, and time permits, the best process is to strip off the turf, level out the ground, and replace the turf as soon as possible, agricultural pipe drainage being introduced if considered necessary.

Assuming the levelling and drainage problem to have been satisfactorily solved, there still remains the ever constant question of the maintenance of the " outfield," which requires far more attention than is popularly supposed. Where practicable, it is desirable to arrange for the ground to be let to a grazing tenant, as sheep keep grassland in good condition, but such tenant has to be under control, and it is necessary for the stock to be penned at intervals, especially if the ground is subject to night flying. In practically every case it is necessary to supplement the natural results of grazing by periodical application of artificial fertilizing agents, and harrowing and reseeding should be carried out when required, the whole object being to maintain the grass with a strong growth which will withstand the impact and skid effects of a high-speed aeroplane.

A petrol roller of a weight suited to the ground is a necessity and should be systematically and constantly used. Generally it will be found that a 2 to 2½-ton roller is quite heavy enough. Too heavy a roller is apt to destroy the under-drainage, damage grass roots, and may " pan " the surface. Cambridge rollers can often be used with great advantage to a grass surface. Other implements necessary are harrows, hay cutters, and a light motor tractor to draw them.

Agricultural implements of the description just mentioned are cheap and a good supply should be available, so that they can be

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brought into immediate use as and when required. Many of the operations on an aerodrome can only be carried out when flying is not in progress, and may involve night work.

Particular attention is necessary along the lines of old hedges and ditches where settlement often occurs after filling in and piping.

Pot holes are easily formed and must be repaired before they become a danger to landing aircraft. Ridges and furrows have a tendency to re-appear, although some time they may have been rolled or otherwise levelled out.

All these, and many other similar conditions, need constant watchfulness to prevent deterioration of the ground. It is not an exaggeration to say that the life of a pilot is at stake when neglect takes place, to say nothing of the loss, which may amount to thousands of pounds, occasioned by damage to a machine.

LANDING GROUND RUNWAYS.

It may be necessary to fix on a site for a landing ground which is on marshy or soggy flat land, and instead of attempting to get the whole area into a fit condition for landing on, it is sometimes sufficient to concentrate on the formation of definite runways for the machines. Runways should be as long as possible and, in order to provide safe landing in all conditions of wind and weather, should box the compass in four or more directions. If necessary, the runways can be raised somewhat above the general level of the site. (Fig. 4.)

The runways may be of concrete or tarmac, or may consist of a consolidated oiled surface, built up on the lines previously described. There is at present considerable difference of opinion between both pilots and engineers as to the best type of surface for runways. Concrete or tarmac is expensive, and is generally considered to provide too hard a surface for fast landing machines, which rely upon a tail-skid for braking purposes, to pull up within a reasonable length. Turf of good, solid growth is, of course, an ideal runway surface where it can be grown and maintained in good condition—but there are many cases of badly drained sites, and of ground which is in other respects totally unsuited to the growth of good turf.

For the proposed runways, then, ruling out concrete or a similar hard surface, at any rate until machines are fitted with other means of braking than the use of a tail-skid, we are driven back to the oiled surface as previously described. Assuming a runway 50 yards wide, it should be slightly cambered with a rise of, say, three inches in the centre, to allow flood water to drain quickly to the sides, and along each side of the runway an adequate French drain should be laid.

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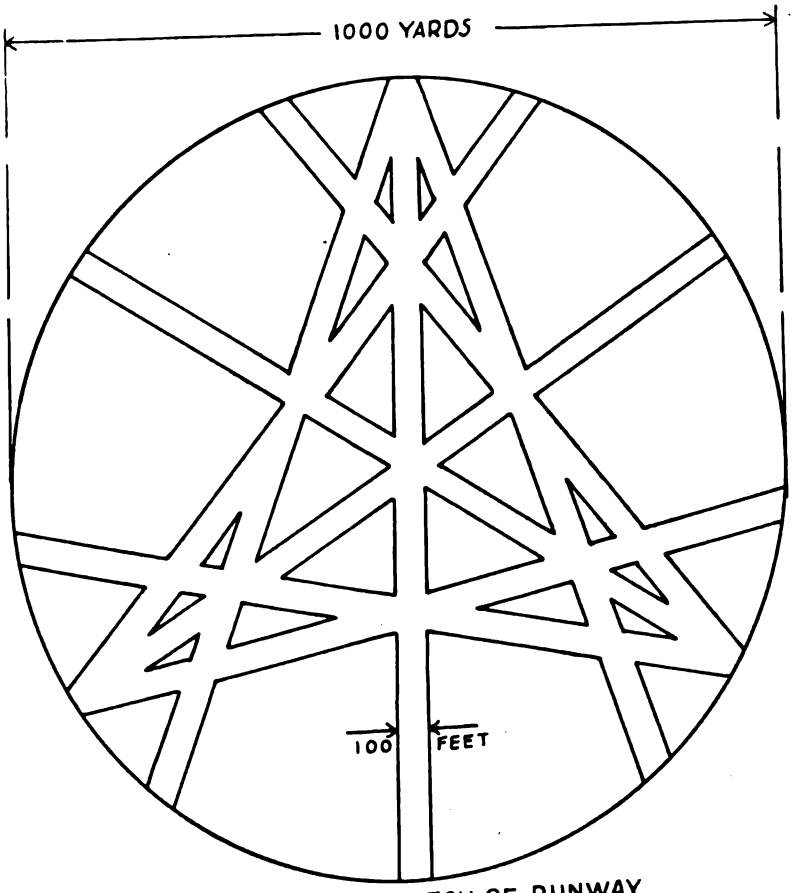
In America, many of the landing grounds are provided with these runways, a typical layout of which is shown in Fig. 5.

It is quite possible that, as the intensity of use of aerodromes increases, the formation of special runways will be a general feature of landing grounds. In India, *e.g.*, there are hundreds of square miles of flat delta land subjected to periodical flooding, where the



DIAGRAMMATIC SKETCH OF RUNWAY ACROSS AERODROME.

FIG. 4.

formation of raised runways would provide landing grounds at a considerably less cost than the alternative of raising the whole surface above normal flood level.

CONCLUSION.

Time has permitted of only a brief survey of the subject, but I have said enough, perhaps, to establish the fact that the care and maintenance of a landing ground is a matter of prime importance,

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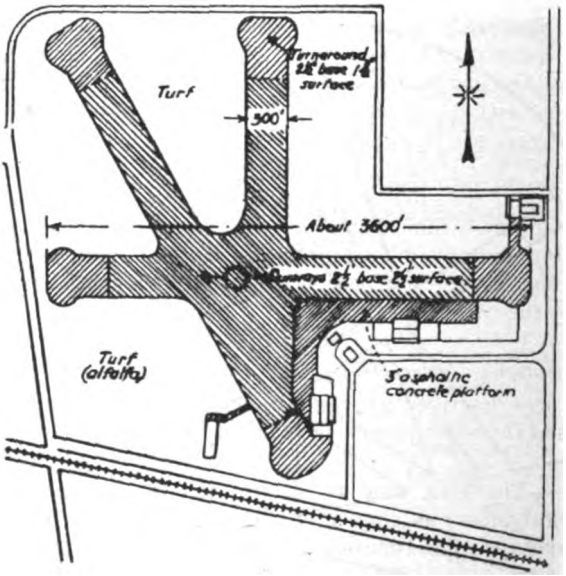
calling for considerable thought, zeal, commonsense and effort by those responsible. The point for all concerned to get well fixed in their minds is that the problem is of a specialist nature, and that the methods of agriculture (good enough for the maintenance of ordinary pasturage) have to be supplemented by special methods of maintenance to meet the extraordinary use to which the surface is subjected when the ground is used as an aerodrome.



LAYOUT OF RUNWAYS AT UNITED AIRPORT, BURBANK, CALIF.

FIG. 5.

APPENDIX "A."

LANDING GROUND—SPECIFICATION OF OIL TREATMENT.

First Operation—Oil Treatment.

1. Remove vegetable growth and cart and deposit where directed.

2. Break up soil to a depth not exceeding 6 in., and as small as possible, so as to ensure a grading of the soil to a degree that any lump will pass a 2-in. mesh in any direction.

For this purpose the "Simar Rototillar" or other similar machine is to be used.

3. After soil is broken up, as above described, the top 3 in. is to be shovelled aside in strips about 3 yards wide, and "Shelspra" added at

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the rate of 1⅛ gallons per square yard to the bottom 3-in. layer of broken soil.

The "Shelspra" to be applied at a temperature of approximately 220°F., and the soil first turned over by hand, and then further thoroughly mixed with the oil by necessary use of the "Simar Rototillar" or other similar machine.

The bottom layer of soil mixed with oil is to be evened out and then to be thoroughly rolled with a 4-ton petrol roller.

4. The top 3 in. of soil over each strip 3 yards wide is then to be replaced, "Shelspra" applied as before described, at the rate of 1⅛ gallons per square yard, turned over by hand and then thoroughly mixed by the use of the machine before described, followed by distribution of the soil mixed with oil, so as to ensure a smooth and uniform surface to the natural gradients of the land. The surface then to be rolled to the extent required to ensure an even, smooth result.

5. "Shelspra" is a road oil, marketed by Shell Mex, Ltd., of Kingsway, and is a pure bitumen fluxed with a white oil to reduce its boiling point. It is to be applied hot at a temperature of about 220°F. as before described, and for this purpose the necessary boilers, etc., are to be provided by the contractor.

Second Operation—Under-Drainage.

6. The area described above to be oil-treated is to be drained after completion of the oiling process, to take storm water off oiled surface, as follows:—

(NOTE.—The area now to be treated is already drained with agricultural pipes, as shown on drawing. The existing subsidiary land drains are approximately 2 ft. below the existing surface, on the average.)

7. The new drains to carry water off oiled surface are to be formed at intervals of 50 ft. apart. To be inclined at an angle of 45° approximately to the front edge of the paved apron.

8. Excavate trenches to the necessary depths (average, 1 ft. 6 in.) and falls from front of apron to outside edge of oiled surface, but *in no case deeper* than the top of the existing land drain-pipes. The top 6 in. of material consisting of soil already oil-treated to be laid aside and afterwards carefully spread over surrounding oiled surface and rolled to make up any inequalities.

Provide and fill in to drain trenches up to within 6 in. of surface level hard broken brick or stone to pass a 2-in. mesh and to be held by a 1½-in. mesh.

Provide and fill in over last to drain trenches to a depth of 3 in. with hard broken brick or stone, as before described, but to pass a 1½-in. mesh and to be held by a 1-in. mesh.

The remaining 3 in. to bring drain trenches up to level of oiled surface is to consist of selected fine soil, not clay, filled in and well rolled on top of the hard, dry filling.

Great care is to be taken in order to ensure porosity, that *no oiled soil* is filled in over the drain trenches.

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APPENDIX "B."

LANDING GROUND—SPECIFICATION OF BURNED CLAY AND OIL TREATMENT.

First Operation—Clay Burning.

1. Strip off the vegetation over the area indicated, load up and cart and deposit in suitable heaps in approved positions for use in subsequent clay burning operations.

Excavate over area indicated to a total depth of 12 in. below existing surface and load up, cart and deposit in heaps, in approved positions for burning.

2. The clay to be burned to a degree *greater* than the standard usually adopted for "agricultural" purposes and equal to the standard normally used when calcination is required to adapt the burned clay for use as ballast, as aggregate in concrete, etc.

To be burned in heaps of suitable size, and the work to be carried out by skilled clay-burners.

Approximately the process should be as follows:—

Start fire with top spit removed and dried, supplemented by sufficient dry brushwood. Cover over with a layer of clay and add fine coal, scattered over heaps in thin layers. As the clay is burned, more clay to be laid on fire, coal added and the processes repeated.

Care is to be taken not to allow the fire to burn out through the external surface of the heap, without applying fresh clay and adding the necessary fine coal.

The burned ballast is then to be screened against a screen of $\frac{1}{2}$-in. mesh, and the coarser and finer ballast to be stored in separate heaps for replacement as described hereafter.

3. The coarser ballast is to be replaced over the excavated area, spread and levelled and well rolled and consolidated with a 4-ton petrol roller to a finished depth of 9 in.

4. The finer ballast is then to be thoroughly incorporated (by turning over the requisite number of times) with "Colas" bitumen emulsion, or similar preparation, diluted with an equal quantity of water at the rate of $1\frac{3}{8}$ gallons per square yard, and replaced over the whole area in one 3-in. layer.

This layer to be spread and levelled and well rolled and the finished surface to be left smooth and even and at the same level as surrounding areas of ground undisturbed.

The "Colas" bitumen emulsion or other similar preparation, described above, can be emulsified in water for *cold* application.

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THE COMBINED DISPLAY, ROYAL TOURNAMENT, 1930.

By Bt. Lieut.-Colonel N. T. Fitzpatrick, d.s.o., m.c., *p.s.c.*, R.E.

The " combined display " at this year's Royal Tournament proved a novel item in the programme. As it was also a novelty in the way of an experience, these notes about the display in particular and the Tournament in general are written in the hope that they will interest those concerned in similar undertakings in the future.

The origin of the combined display was most fortuitous. A biggish parade ground demonstration, given by the 17th Field Company, R.E., to O.T.C. contingents, in August, 1929, proved of such surprising interest, that, with a light heart and without any knowledge either of Olympia or Tournaments, the venturesome suggestion was made that something of the sort might be put on at the Royal Tournament of 1930.

The suggestion found favour, we were asked to send along a cockshy of what it was thought could be done, and so, still without any " producer knowledge " either in front of or behind the scenes in London, we got busy with a plot. We remembered that the length of the tan in the arena was some four times its width, and that the dimension of the latter was about that of a cricket pitch. We also took it that the whole turn should last fifteen minutes at the most and we cast about for something which would portray, if possible, a real life affair, with a connected story running through it and the maximum amount of snap in execution.

The net result of a short deliberation on the matter was the conception that the turn should be a river crossing and a plot was worked out showing how it was proposed to make a " river " with its " banks," " throw " three bridges across, " throw " real troops over and " throw " the whole party in and out of the arena in fifteen minutes.

The cockshy was accordingly written up on these lines. The whole plot, on a sheet-and-a-quarter of foolscap, went duly forward, through the Divisional Commander (who gave it his blessing, together with " Lightening, London," as the Company's telegraphic address) and thence onwards and out of our minds for many months —till suddenly, in January, 1930, we heard that the plot in its original form was " approved."

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This was more than we had really bargained for. We imagined that, even were our scheme ever approved, it would have been returned with all manner of comments as to what was and what was not considered practicable, but the only instruction we received was that the whole turn should on no account take more than fifteen minutes. How it was all to be done was entirely the "producer's" affair, and it was left to us to discover the means of giving tan the buoyancy of water and turn the cockshy into a practical proposition.

We got busy, taking it from the outset that the plot in its original form would somehow prove practicable, and the following plan of operations was sketched out :—

Experiment forthwith and decide as early as possible on the means by which the Kapok Assault Bridge, the 30-cwt. raft, and the Light Box Girder, could be "thrown" (as realistically as possible) across 40 feet of camouflaged "wet gap" laid on a dry arena. The whole to be capable of being made and dismantled within the allotted time. Ruling factors: reality, pace, simplicity. Maximum Sappers available, 80.

Complete experiments and order all gear required by 1st April.

Have all gear at hand by 1st May.

Rehearse and complete the technical side of the operations by 12th May.

Rehearse at Bulford as a combined force with R.A., Light Tanks and Infantry, 13th to 24th May.

To London, 25th May.

Rehearse Olympia, 26th and 27th May.

Opening show, 28th May.

The first bridge to be tackled was the Kapok Assault of seven bays.

To maintain the semblance of reality it was essential that the normal equipment should be used and we had to devise a means by which the complete length of bridge could be launched and delaunched in one motion and as it would be handled in real life.

After trying out various methods of acquiring "buoyancy," simplicity personified won the day. The bottom of each float was armoured with a sheet of three-ply with two hard-wood guide buttons attached to the under side; and across the camouflage river was laid, as part of the scenery, a slide way of two wooden rails—upper surface planed and polished. These simple fitments successfully eliminated the "μ" of tan and the whole bridge became capable of being launched and delaunched in a most realistic manner, *vide* Photo No. I.

To save arena time, it was decided that the bridge would have to

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enter the arena already assembled for launching, and that the portability of this bridge would be demonstrated by dismantling and loading aboard a light six-wheeler on the " far bank."

Having tried out the whole operation from the drill point of view, the whole issue was sent off early in April to our friends the Dorsets at Portland, where they rehearsed on their own and became word-perfect in Kapok work before joining up at Bulford for the combined rehearsals.

The next affair to be dealt with was the light raft for ferrying over the close-support vehicles, *i.e.*, Carden-Loyds, weighing 30 cwt.

Here the original plot took up for a home-made type of Kapok raft, but on talking things over with the R.E. Board, the suggestion was made that our raft should be replaced by the new Folding-Boat gear.

The suggestion was immediately followed up and after visits to and help from Christchurch and Mr. Straussler, the designer of the Folding Boats, we decided that this project was feasible, provided we could obtain the very latest pattern of boats with quick-spring-folding arrangements, and provided also that we could have specially light superstructure built up for the show. The question of transport also called for special consideration, since the plot necessitated the whole of the raft equipment both entering and leaving the arena on M.T.; these 21-feet-long boats entailed in consequence the design of some special form of transport, which would lend itself to particularly quick loading and unloading in the arena. The manner in which the boats were to be " launched " and " floated " on tan was, however, allowed to remain a mystery, until trials solved the preliminary unknown as to how these boats would behave when carrying a light tank on dry land instead of water.

The new boats were obtained, the special superstructure was designed by the Company metaphysicist, and built up for us in record time by Mr. Straussler, the day for the folding boats' novel experience duly arrived, and the raft was assembled on a football field.

Up crawled the first light tank and the raft rocked about in a realistic manner, but all went well, till the driver, who had been so impressed upon to creep across at minimum speed during the trial run, stalled his engine and stopped dead at the critical position of the middle of the centre span; then, in an attempt to regain momentum in the most delicate manner possible, the driver suddenly made his vehicle execute a series of most astounding pig-jumps without any forward movement, all in the middle of the centre span. These astonishing evolutions produced impacts far and away above that allowed by the metaphysicist, and the road-bearers

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carried out in rapid succession a series of deflections that must have surprised the whole hierarchy of prime Oregon. However, everything held, a series of runs was then successfully carried out in low-reduction gear and the behaviour of both boats and superstructure showed that the scheme was practicable as regards loads.

Next came the question of transport for the boats. Each folding boat crew numbered eight men, who had to enter the arena seated in their personnel light six-wheelers, and we had to devise the most compact means of taking boats and crews up to the river on one side and away on the far side. Various schemes of slinging the equipment on to the personnel vehicles were tried out, but had to be rejected, the use of a Carrimore had also to be discarded owing to loading which would not have been handy enough for arena purposes, and so it became necessary to design a special trailer for each boat. In this matter, as with many another, our friends in the Ordnance Depot at Tidworth proved invaluable, and from a sketch design and specification they produced a brand-new trailer in a fortnight, followed this up with a second a week later, and the whole outfit worked admirably.

The last problem with the folding boats was their "flotation." Here, brute force, strip parquet, lino, slideways, etc., all proved of no avail, and we eventually hit on the plan of launching them out on rollers. These were put together in frames the width of the "wet" gap; over the rollers one was able to push out and haul in the boats in quite a realistic manner, and the boats proved themselves truly noble in the way they stood up to taking their loads whilst on the roller bearings.

Photos II and III show how the folding-boat gear worked.

The final bridge to be tackled was the Light Box Girder. As in the case of the Kapok Assault Bridge, we decided, on account of time, that each girder would have to be run in made up complete with launching noses (2¼ tons each girder) so that it could be launched straight over and leave only the handling of the launching noses, decking and riband work to be done in the arena. Considerations of time and space also prevented the girder transport (one medium six-wheeler per girder) being used during dismantling, and owing to the 90 feet of length of the assembled girder it was impossible to send them out of the arena with the rest of the combined force *via* the Addison Road Entrance. We decided, in consequence, that the place of assembly for the girders would have to be taken as being outside the arena at the Blythe Road end, that the girders would have to return always to a "park" at that end and that this matter should be explained in the programme.

The necessary means of running the girders up from their "park" to the arena river was happily to hand in the company in the shape

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of two axles of the Reavell compressor. The standard launching rollers were raised, so that the girders, after travelling in on the compressor axles, could be slid off on to the rollers, and the width of the river was so adjusted that with three sections of girder—48 feet—the weight could be taken by a party on the forward launching nose before the front of the girder bit into the tan and camouflage.

All this turned out to work satisfactorily (see Photo No. IV), and all we lacked was a complete new set of launching noses, for those sent up with the girder had been already " tested to destruction " and made quite unserviceable for Olympia. Five new noses were accordingly ordered early in March, from Messrs. Boulton & Paul, for delivery by 1st April, and thus the purely technical side of the turn was more or less finished.

There remained on the construction side only the provision of a " river " and " banks " which could be brought in and set up in the arena with due accuracy as regards the positioning of gaps, rollers and slides. The whole of this scenery had to be capable of being set up in one minute and dismantled in half a minute with one carry of 40 men.

Here again, Ordnance, Tidworth, were invaluable. Nothing seemed too much trouble for them, and they undertook to do any stitching and painting which proved beyond the resources of a company's shops.

The two 80 feet by 12 feet " banks " were made up out of old marquee canvas walls, sewn together and mounted on four panels per bank. Each panel was kept down to a two-man carry, and the canvas on each set of four panels was arranged to open out into the 80 feet by 12 feet " bank " with three " gaps," one for each bridge.

The " river " was the bane of our lives. Here we required a camouflage stream 80 feet by 40 feet. This obviously had to go down in two halves and required the lightest possible hardy material for the job. After thinking of various materials, but having had to reject them all for one reason or another, we eventually decided on balloon fabric. This substance we hoped to find just right in weight and hardiness ; also we pictured it just the right colour, a sky-blue which would only need " flecking " with white to give the exact contrast we had in mind of bright water between the banks camouflaged up green, yellow and brown.

What with one thing and another, however, we did not " arrive " at this fabric idea till just before Easter, by when time was getting on and there remained only a few days in which to obtain a balloon before Easter. Telephonic application being made to the R.A.F. it was found, as was almost to be expected, that the R.A.F. were

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hardly accustomed to supplying balloons to individual members of H.M. Forces. One and all, however, were most helpful in quoting the particular superior authority from whom they generally obtained balloons and so the telephone request—"Could you possibly give me a spare balloon"—went on and on up the aerial tree. Finally, by our importunity in 'phoning an Air Marshal at his Sunday breakfast, combined with the A.M.'s truly wonderful equipoise under such a trial, we were at last able to send and obtain delivery just before Easter.

Having landed our balloon in triumph, a chance enquiry at Olympia about its dissection resulted in us being told that balloon fabric was the *bête noire* of the Olympia fire brigade, and that neither they nor various other bodies connected with Olympia would let us come near Olympia, the Tournament, or anything else connected with the coming party, if we had a vestige of this fabric about us.

The fat was now properly in the fire, for there we were within a few days of featuring in this river crossing episode but without any semblance of our "river."

A visit had to be paid post haste to the heart of the City, where we learnt of a place which did supply materials for non-combustible rivers, and down the material was brought by the next returning passenger train. Immediately on arrival, all the sempstresses in the Ordnance got busy cutting and sewing it up, and then on went the painters to work to an overtime limited only by the short summer nights of May.

Our special train was due to leave Bulford on a Sunday morning; by the Thursday afternoon, one half of our river had been finally painted and we were beginning to breathe freely again when down came a thunderstorm, complete with a cloud-burst, which nearly washed the Ordnance Park away and completely washed our half-river away. We eventually took delivery of our "stream" a few hours before the train left and our first trial was at Olympia—however, all was well on the day and the photographs show how the scenery worked.

So much for the construction, and now as regards rehearsals. The powers-that-be were extremely good and put the whole combined force—Davey's Section of 7th Light Battery—Dean's 2 Sub-sections Light Tanks of 5th Bn. R.T.C. and Spencer and Wood, with their 2 platoons of Dorsets (some 75 strong and probably the strongest platoons in the Kingdom)—under me from 13th May, and we rehearsed, worked and played together for the fortnight before coming up.

Owing to the way in which the moves of all components of the combined force had to dovetail in with one another, rehearsals had

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to be carried out on a full-size replica of marshalling area, arena and exit. The exact site was providentially close at hand in the lines of the 26th Field Brigade, R.A., who were extremely kind in lending it all to us. As a result, we were able to coach every man to become *au fait* with every detail as regards the real site, and also to tell the Tournament Committee exactly what the marshalling of the unusual combined force entailed, so that the special arrangements necessary for stables and our parking could be made beforehand.

As regards the actual rehearsals. The various movements were gradually worked up together; first, we went through the Sapper moves and obtained a general knowledge of what latitude was available, then the parts of the Gunners and Tanks were arranged for and, finally, the working of the Infantry was dovetailed in. After concentrating on the space problem during the first week, we concentrated on time during the second, and eventually we left Bulford knowing, as far as one could, that we would be able to do the show in fourteen minutes.

The turn being an all-arms one, both in spirit and in fact, it was essential for the force to acquire an *esprit de corps* as a force before going up to London, and this we got by games at Bulford. Inter-unit football, cricket, sports, etc., ending with a concert, did the trick, and the whole army went up to London on the 25th of May, right on its toes and all together.

Rehearsals at Olympia led to extraordinarily few changes; we found that the making of any, even the most minute, was impracticable without a special rehearsal of that particular point, whilst our arena allotment only allowed time for a couple of runs for our scene shifters and two full-dress rehearsals. In consequence, we opened up without any change, and the programme description of the turn is attached in the Appendix.

As regards the actual performances. During the first few shows there was a certain amount of stage fright, but after a very short time this wore off and then the only effect of the big audience was to make each man do his very best.

To commence with, the Committee insisted on us being the last turn in each programme. Our work-a-day affair, however, was not the best ending for a programme which was full of shows of pomp and glamour, but even when we were last, it was remarkable that this turn held a crowd on the point of dispersal as well as it did. After a few performances, our display was brought on in the body of the programme and all went very well; people were struck, as "A.A." said in *Punch*, how the forcing of a river passage by an army could be accomplished in less time than "A.A." himself could normally force his individual passage across Piccadilly Circus.

Photos V, VI, VII and VIII show respectively the display when

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starting, with bridges nearly ready, traffic going over, and towards the end of the turn.

Throughout the time, one was somewhat on tenterhooks as to whether everything would work out exactly right, for although the handling of all the gear came to appear pretty simple, there were, as a matter of fact, many small things which might somehow have gone adrift and upset matters. We were, however, very fortunate, detailed inspections after each performance took up for the stitch in time, and, thanks to the way everyone did his utmost, we carried out our 33 performances and did the show before a total audience of a quarter of a million with only one hitch, which was caused by incorrect placing of rollers.

The numbers in the combined force came to 8 officers, 230 men, 21 mules, 2 guns, 6 light tanks and 8 lorries.

As regards expense: after disposing of gear on conclusion, the turn cost the Tournament about £300 for special equipment and scenery, the latter remaining in London as Tournament property.

Our conclusions about putting on a turn at Olympia are many, but the following seem most worthy of note.

About the show to be given at the Tournament. It is strongly recommended that any turn should be initiated and directed by someone who has had previous experience of the Tournament as an actual performer; there are so many facts and factors which can only be appreciated by those who have been "on," and without this knowledge a "producer" is at a considerable disadvantage in not knowing exactly what can be staged and what will go down.

The circumstances are peculiar and the situation is a fairly big one. The primary object of the Tournament is to make money for Service charities, the majority of the audience is non-military and will only pay to go and see what it likes. There are certain types of displays that the public and Press know they like, *i.e.*, displays with pomp and ceremony, such as pageants and musical rides, brisk turns with an element of danger, such as naval field gun displays, artillery drives and the rope-climbers, items which demonstrate great precision of movement such as arms drill and P.T., whilst any affair of at all a humorous nature is immensely popular. But one would be well advised to be careful in putting on anything too technical, instructive and work-a-day, which is devoid of glamour and pace. The small section of the daily audience of 16,000 who are militarily connected may read a programme description of anything new, but to the bulk of every audience each turn must be in itself obviously bright and arresting. There were no loud-speakers at the Tournament, but if these are introduced they would help considerably with shows like ours. Those who have been through a Tournament could make a pretty shrewd guess as to what reception a proposed turn would meet

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with, but without that experience one could hardly make an accurate forecast.

Again, in framing a turn, both audience and men have to be considered in connection with applause. The former cannot be expected to applaud during each item unless presented with obvious " curtains," the men naturally get downhearted unless they receive their due meed of praise, and last, but most important, is the fact that, in the genuine interests of the arm concerned with any item, one must to a certain extent play to the gallery, which at Olympia is a big one. The only stage effect we worried about during rehearsals was our instruction to be in and out in fifteen minutes: the only " curtain " that ensued was an empty arena. This naturally did not give anyone a chance and one might have been tempted to try to alter the display in various respects. The introduction, however, of any alterations, no matter how small, cannot be risked without full-dress rehearsals, and as the opportunities for these at Olympia are so few, a turn has really to stand in the manner rehearsed before going up to London. We were, as a matter of fact, able to work up a few curtains, such as halting all traffic on the near bank to commence the crossing all together, but with previous experience of Olympia, we probably would have staged the show differently.

In arranging the staging of a turn, the length and width of the arena, together with the way the seats are arranged right round the arena, also deserve accurate appreciation. The arena is some 300 feet long by 80 feet wide, and the top row of gallery seats extends some 50 or 60 feet outside the whole of the actual arena perimeter. Owing to the distances thus introduced and the angles of vision, one should avoid doing anything within about 15 feet of the arena surround and the best type of display is the one which continuously fills the whole centre of the arena.

The correct selection of music also plays a far more important part than one imagines and requires very careful consideration. The same remarks apply to the positioning and details as regards stance of every man, and as for timing, the success of any turn lies largely in its amount of " go," and this depends on full use being made, not merely of every minute, but of every fraction of each second.

Lastly, and as regards matters off the stage, it should be borne in mind that the interest taken in equipment by the public, who walk round behind the scenes before and after the programme, makes it very well worth while to arrange park or stables in a really attractive manner with bunting, etc.; it may cost a bit but it is well worth while.

In conclusion, one feels bound to make some remarks in general about the Royal Tournament. It is an excellent opportunity to fly the flag for Corps and Service, and at the same time all taking part

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derive a wealth of good from their labours. Getting up a show, particularly a technical one, develops ingenuity and determination, appearance in public develops confidence, and all who go up to Olympia meet other arms at close quarters, make many friends and learn much of skill-at-arms in all branches of the Service. The whole affair was run in an extraordinarily happy manner under the honorary secretaryship of Brig.-General Sir Wallis King, a host in himself, and I am sure that it is well worth while for each arm of the Service to do its utmost to put up a show at the Tournament every year.

APPENDIX.

COMBINED DISPLAY BY ARTILLERY, ENGINEERS, INFANTRY AND TANK CORPS.

The Passage of a River.

This Display shows how troops and the vehicles which must accompany them can rapidly be provided with means of crossing a water obstacle. The leading Infantry cross by means of an assault bridge, which they carry up and launch themselves. The first bridge to carry vehicles is provided by a folding boat, which is brought up, launched and put in position by the Engineers. Another bridge is necessary to take the heavier vehicles, such as Field Artillery and lorries. This is a girder bridge, which is brought up and put into position by the Engineers. The units taking part in the Display are the following: one section, 7th Light Battery, 2nd Light Brigade, R.A.; 17th Field Company, Royal Engineers; two sub-sections, Light Tank Company, 5th Bn. Royal Tank Corps; two platoons, "A" Company, 2nd Bn. The Dorsetshire Regiment. The detail of the actions is as follows:—

The arena is set with a river, about 40 ft. wide, across the centre; a small patrol of the enemy is watching this obstacle from the far bank. Armoured fighting vehicles approach and open fire. They quickly force the enemy patrol to withdraw, then move up to the river, which they find they cannot cross. The leading Infantry follow close behind the armoured fighting vehicles, and are also brought to a standstill by the river. Reconnaissance for bridging operations takes place at once. Meanwhile, two light Artillery howitzers approach; one comes into action at once to cover the crossing, the other is off-loaded close to the river and the mules are taken back to join the rest of the pack animals.

The Infantry then carry forward and launch the assault bridge. As soon as it is over the Infantry double across to form a bridgehead to cover the further bridging operations. The assault bridge remains across the river, the only means of communication with the forward troops. The Engineers now bring up the materials for the folding boat bridge

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COMBINED DISPLAY, ROYAL TOURNAMENT, 1930.

Rehearsals at Bulford Camp.

Photo I.—Launching Infantry Assault Bridge.

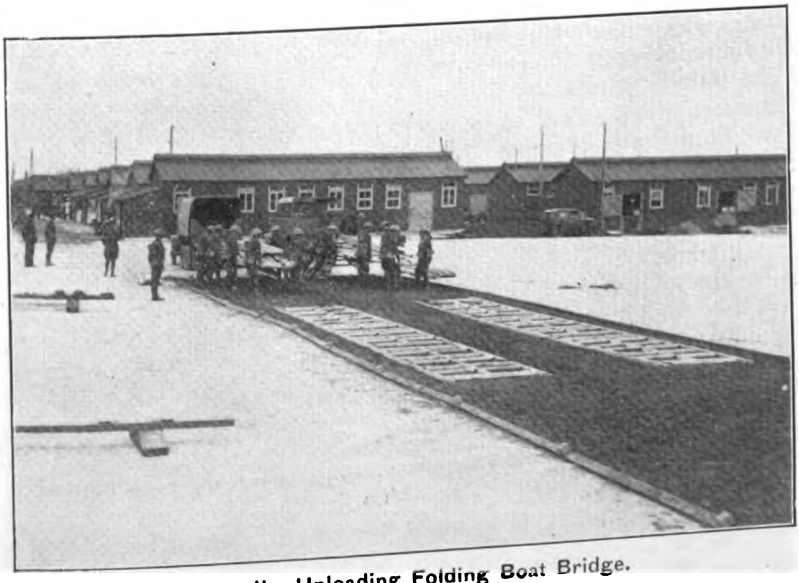

Photo II.—Unloading Folding Boat Bridge.

With acknowledgments to Photopress, Ltd., Fleet Street, E.C.4.

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Rehearsals at Bulford Camp.

Photo III.—*Folding* Boat Bridge.

Photo IV.—Light Box Girder Bridge, and in background the Reavell Compressor Axle fitted with a Cradle.

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Performances at Olympia.

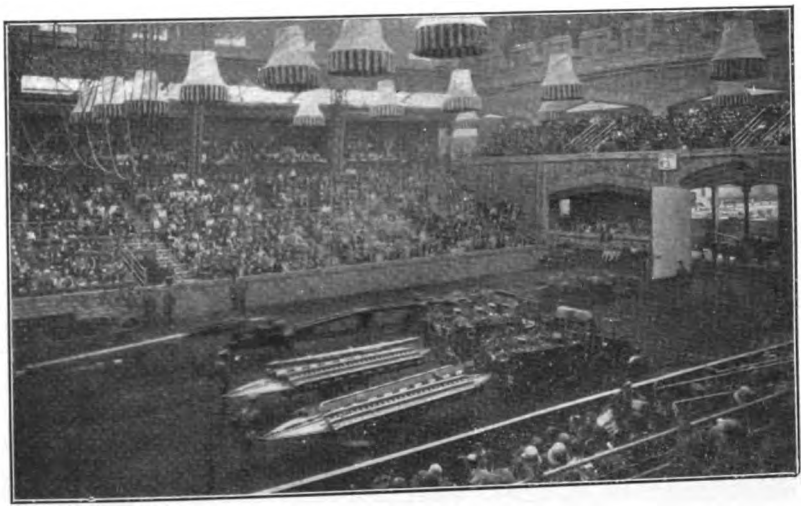

Photo V.—Entering the Arena.

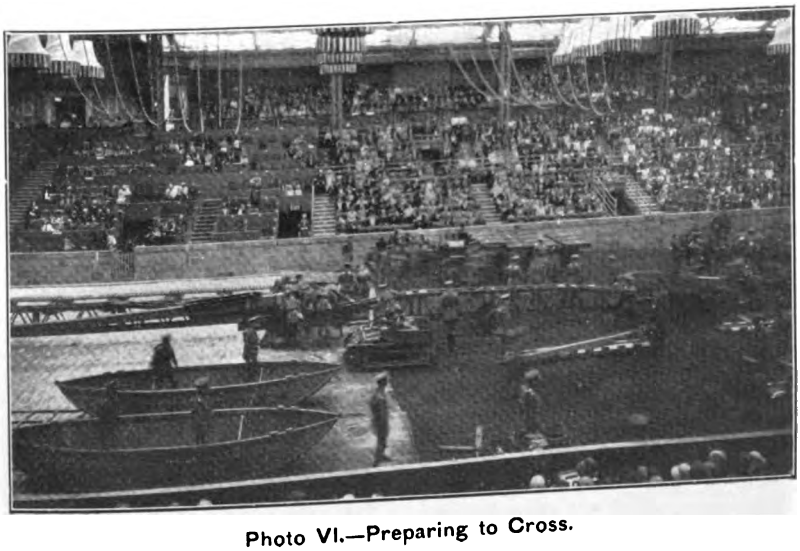

Photo VI.—Preparing to Cross.

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Performances at Olympia.

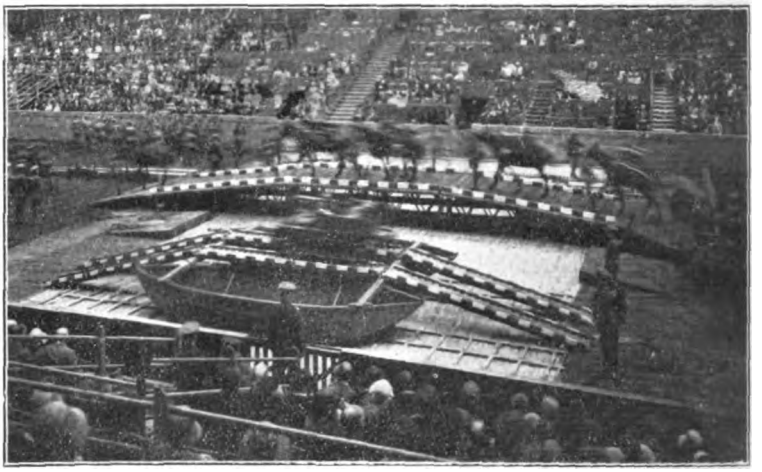

Photo VII. - Light Artillery and Light Tanks Crossing.

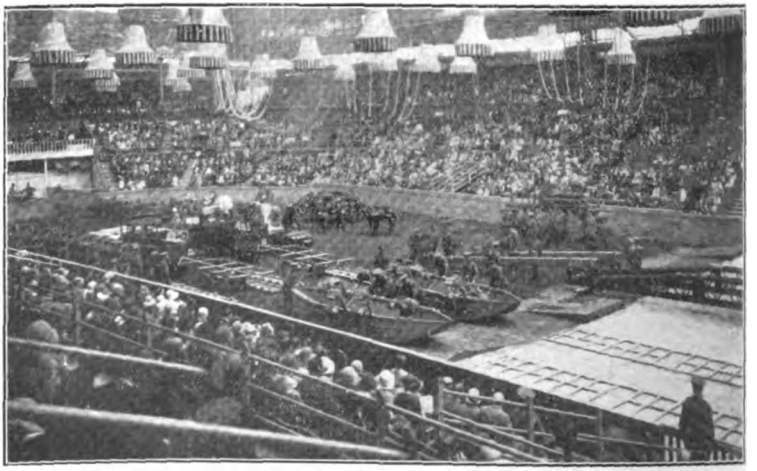

Photo VIII.—Dismantling after Crossing.

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and launch and build the bridge. As soon as it is completed, the armoured fighting vehicles cross. These are closely followed by the howitzer, which is man-handled over to come into action on the further side.

Meanwhile, the Engineers have been assembling a heavier girder bridge which is needed to take over the rest of the Field Artillery and other heavy vehicles.

The advance continues; the Infantry load up the assault bridge; the Artillery move forward; the Engineers take out the folding boat bridge and load it up on the farther bank. The troops advance out of the arena, Infantry and armoured fighting vehicles leading, followed by the Royal Artillery and Royal Engineers.

Owing to the circumstances in which the Display is produced, there is not time nor space to show the lorries which carry the Box Girder Bridge, which has consequently to be taken in and out of the arena on trolleys.

The impossibility of having water in the arena makes it necessary to place slide-ways on the ground in order that the floating bridges may be launched in the same way in which they would be put into a real river.

The following are the approximate times taken to complete the stages of the Display :—

Assault Bridge is over at the end of the 1st minute.

Folding Boat Bridge ready for Armoured Fighting Vehicles at the end of the 4th minute.

Box Girder Bridge ready for traffic of 12-ton load at the end of the 6th minute.

Assault Bridge dismantled at the end of the 8th minute.

Folding Boat Bridge dismantled at the end of the 9th minute.

Box Girder Bridge dismantled at the end of the 13th minute.

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RESTORATION OF WHITBY WATER SUPPLY.

By LIEUTENANT C. E. MONTAGU, R.E.

IT has been suggested that the following brief account of the recent breakdown of the Whitby water supply and the part played in its restoration by a detachment of the 55th Field Company, R.E., may be of general interest, as the time factor and working conditions more closely resemble those met with on active service than those usually encountered in peace training.

GENERAL SITUATION.

Sleights is a small village situated four miles up the Esk Valley above Whitby. The village is divided into two portions by the River Esk, which was spanned by a masonry road bridge.

This bridge carried the Whitby water supply mains, which consisted of an old 7-in. C.I. pipe laid in 1864, and a newer 8-in. C.I. pipe dating from 1924. These pipes connected the high-level reservoir at Randy Mere to the local Sneaton Castle reservoir ; the head of water at Sleights being about 450 ft. The Randy Mere reservoir is 6 miles up the valley above Sleights on Egton High Moor, and is marked " R " on the map. It holds 13,000,000 gallons, while the Sneaton Tanks are 3 miles below the village and have a capacity of only 750,000 gallons. The latter figure represents about two days' supply for Whitby during the holiday season.

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THE FLOODS, JULY 20TH TO 23RD. (*Sunday to Wednesday.*)

From the afternoon of Sunday, July 20th, heavy rain fell almost continuously over Yorkshire until Wednesday morning. This was particularly severe in the constricted valley of the Esk (over 11 in. being recorded) and the river level rose in places to 24 ft. above normal. Amongst much other damage to property, the Egton and Sleights Road bridges were swept away and several railway bridges between Grosmont and Sleights were damaged. It was remarkable that only one life was lost from drowning, when it is remembered that the water was in places 8 to 10 ft. above road level and cottage floors.

Sleights bridge itself gave way in the early hours of Wednesday, July 23rd.

REPAIRS, JULY 23RD TO 25TH. (*Wednesday to Friday.*)

On hearing of this failure, the Whitby Waterworks Department engaged a Newcastle contractor to effect temporary repairs. This contractor was engaged in work on the Whitby sea front and was thus able to get his labour on the site at once. Owing to the height of the floods and lack of material, progress was slow, however, and it was not until Thursday night that a light structure was got across. The old masonry piers had fallen, leaving gaps of 51 ft., 47 ft. and 33 ft. to be spanned. The fallen masonry was concreted up to take light trestles, upon which were supported three spars per bay. The spars were cut close to the site, averaging seven inches in diameter, and were very whippy. They were launched on a two-inch S.W. cable, which had been got across with lines thrown by the local life-saving apparatus. A trestle in the longest gap was also placed.

Meanwhile, the water company were getting seriously disturbed. Their daily consumption had not been appreciably cut down by appeals for economy, and by Friday morning the Sneaton reservoir was empty.

They had wired on Thursday for their consulting engineer from London, and had telephoned to the Chief Engineer, Northern Command, to ask if any R.E. assistance could be given. As a result, Mr. Hawksley, of Messrs. T. C. Hawksley, Westminster, arrived at 9 a.m. on Friday, and two officers from Catterick visited the site at 11 a.m.

Efforts to obtain suitable piping for connection across the gap had, up to now, produced nothing, so it was most fortunate that a stock of 9-in. Victaulic pipe was lying at the Pumping Station near Catterick Camp. This was to have been used for extension work in the following week, but permission to borrow it was obtained from the C.R.E. by telephone, and seven 18-ft. lengths arrived at Sleights on Friday evening.

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During the afternoon, War Office approval was obtained for the 55th Field Company to give any assistance possible, and after returning to Barracks at 4.30 p.m. after a long day, a party of one officer and 18 other ranks was collected and dispatched by private bus at 8 p.m. They arrived about midnight and were billeted in the local Institute, close to the bridge site. It was arranged that they should commence work at 6.30 a.m. on Saturday morning, when the night shift went off duty.

Meanwhile, some 4-in. steel piping had been obtained from Middlesbrough, and by 1 a.m. on Saturday morning had been got across the spar bridge and connected up to the 7-in. main. The night work was carried on with the aid of five large acetylene flares which were most effective. This 4-in. pipe, however, could not alone deal with the demand, and until Saturday afternoon was only capable of filling the main pipes and getting a little head into the Sneaton Castle reservoir.

Sanitation was at a standstill; thousands of visitors were cancelling their holiday bookings and the Whitby Waterworks telephone line (and operator) was overheating!

R.E. WORK, JULY 26TH TO 27TH. (*Saturday to Sunday.*)

The Sappers started work at 6.30 a.m. on Saturday and were fully occupied until 9 p.m., meals being taken by shifts.

Some 40-ft. lengths of 12 in. x 6 in. timber had been obtained during the night and these had to be substituted for the light spars, as the latter had too much whip to deal with the 9-in. pipe. The work of substitution without starting the leaded reducing joints of the small main was tricky, and in the end it was only found possible to change over two longitudinals per bay. Strengthening of trestles with additional legs and bracing was carried out and concreting-up of pier bases was commenced to prevent scouring or settlement.

The work was visited by C.R.E. during the morning, and a second officer with 12 other ranks were sent over from Catterick, arriving in time to take on the night shift from 9 p.m. to 5 a.m. Sunday morning, in conjunction with six of the contractor's gang.

During this period, the general strengthening of the bridge continued and a portion of the 9-in. pipe was laid. This was supported on 9 in. x 3 in. timber nailed across the road bearers at 3-ft. centres. Owing to the original pipe alignment and position of the fallen piers, the line of the 9-in. pipe was far from central on the bridge, while the 4-in. pipe described perforce a truly wonderful curve.

It was water, however, not symmetry, that Whitby wanted, and by mid-day Sunday the 9-in. pipe was running full. By cutting off the rim of the Victaulic pipe, it was just possible to make the connection to the old main with 8-in. collars.

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From this point onwards, the time factor ceased to be of much importance and all civilian labour was withdrawn, while a normal 8-hour day was worked by the R.E. detachment.

Precautionary Measures.

Once the 9-in. pipe was through, the problem arose as to how to keep it there.

Although the river had now returned to its normal level, it was obvious that if any serious rise should again occur, the temporary structure could not hold.

To attach the pipe to a suspended cable seemed the best solution, and work on this was put in hand at once. It was not considered advisable to take the weight off the bridge on to the cable, owing to the likelihood of starting end joints when water was urgently needed. It was, therefore, attached with slings adjusted to give the correct curve. The joints between 18-ft. lengths give about three inches' play, so it was anticipated that only the end joints would need re-making if the bridge went.

The weight of the pipe line came to approximately 3 tons, and the necessary 3-in. S.W. rope was obtained from Middlesbrough on Monday, July 28th. Two-inch slings were obtained locally. Cable piers, 15 ft. high with 12 in. x 6 in. legs, were erected, and the cable taken to anchorages consisting of double 12 in. x 6 in. timber, 6 ft. long, buried 4 ft. and concreted-in. The siting of these to avoid pipes and other obstacles required some care.

The only possible position on the north bank was within 18 in. of a railway siding. After waiting an hour for permission from a railway engineer who never turned up, sleepers were cut and excavations started. A load of concrete aggregate was dumped on the line to settle finally any question of traffic before the anchorage was complete.

About two feet down, a telephone cable carrying 25 lines materialized —plumb on the line of the suspended cable! Fortunately, it was possible to draw through about 4 ft. of slack and divert the lines round the edge of the excavation, where they were boxed in to prevent damage.

General work on strengthening the bridge and masonry piers proceeded simultaneously with the cable work and the job was completed on the afternoon of Wednesday, 30th.

Two-inch bull-dog clips for sling attachments were not immediately available and the work of obtaining these and substituting them for inferior clips and half-hitch attachments was left to be done later locally.

The interest in the work displayed by the general public was somewhat embarrassing at times, and police were finally detailed to keep the site clear.

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NOTES.

Liaison.

It was anticipated that some difficulty as to control would be experienced, as there were on the site (*a*) a civilian contractor and his labour, (*b*) Waterworks Department labour, (*c*) Mr. Hawksley, Consulting Engineer to Waterworks, from London, (*d*) R.E. Detachment.

Actually, no trouble was encountered. The contractor merely became a supplier of material and stores, while his labour worked under Mr. Hawksley with the Waterworks men. The R.E. Detachment remained under their own officers, who assisted Mr. Hawksley whenever possible. This gentleman worked like a Trojan and, except for meals, was actually on the site continuously from 9 a.m., Friday, July 25th, to 12 a.m., Sunday, 27th, when he returned to London.

Tools.

The R.E. Detachment brought a limited supply with them and had also the use of contractor's tools when required. Care had to be taken to prevent loss or confusion, and deficiencies were few.

Materials.

Except for the Victaulic piping and a few bull-dog clips, spikes and dogs, all material was supplied by the contractor. It was arranged that bills for replacement for the articles from Catterick should be sent direct to the Waterworks Department.

Transport.

One private 35-seater bus and one R.A.S.C. medium 6-wheeler were used for transport of the personnel, kit and tools. The charge for these was borne by the Waterworks Department. The carriage of the 9-in. piping was arranged direct by the Department.

Rations and Accommodation, etc.

Rations for three days were carried from Catterick. The Detachment were put on the higher rate of ration allowance for the remaining two days and food was bought locally. Coal and light were provided free in the local institute. This was comfortable and clean, with a kitchen and all necessary sanitary arrangements.

FUTURE PLANS.

The present structure is only intended to carry the two water mains and is the property of the Waterworks Department.

No site for a permanent bridge has as yet been fixed, but the county authorities propose constructing a semi-permanent road bridge just upstream of the present site and hope to complete this early in September. Provision for carrying the water mains is being made on this bridge, as it is not likely that the permanent bridge will be put up for several years.

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RESTORATION OF WHITBY WATER SUPPLY.

The old bridge completely submerged on the morning of July 23rd.

Fallen pier used as base for a temporary trestle. 16.00 hours, July 26th.

Both pipes running full. Midday, July 27th.

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View from north cable pier, July 29th, showing level crossing gates just behind the south anchorage.

Cable in position with temporary sling attachments. July 30th.

The temporary bridge looking downstream, showing preparations for foundations of the semi-permanent road bridge.

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NOTES ON THE ENGINEERS OF THE U.S. ARMY.

By " PONOCRATES."

IT is always of interest to discover how someone else is setting about a task similar to our own. For this reason, the following notes are offered on the Engineers of the U.S. Army. As will be appreciated from the magnitude of the undertakings placed under the charge of American military engineers, at the present time, this foreign corps is one well worthy of study.

(A) STRENGTH AND ORGANIZATION.

(*i*) *In Peace.*

The American " Corps of Engineers," as it is entitled, has a regular peace establishment of about 560 officers and 5,000 other ranks, though, as in the case of other arms, the American authorities maintain this Corps often much under strength. These figures compare with about 1,150 officers and 7,100 other ranks in the case of the Royal Engineers. It has to be remembered, however, that whereas the British Army at home and abroad numbers about 210,000, the corresponding figure for the Regular American forces is only 125,000. Most of the American Regular Army units in peace are maintained either in cadre form or in detachments. The peace distribution of Engineer units is not, therefore, of great interest.

In addition to the regular personnel, the 18 National Guard Divisions and 27 Organized Reserve Divisions have the same proportion of Engineers as the regular divisions, though not fully recruited in peace.

(*ii*) *In War.*

The infantry divisions of the U.S. Army each contain one " combat regiment " of Engineers, and the cavalry divisions one " combat battalion, mounted." These units perform all the engineering duties required within the formations concerned. In war, for engineering tasks outside the province of divisional engineers, the Americans contemplate employing " general service regiments," the number in the field varying according to the numbers of Army Corps. They correspond closely to British Army Troops Companies and are responsible for construction of roads, bridging, railways, installation of water supply, electrical and mechanical duties and supply of stores.

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In addition to these divisional and non-divisional units, a large reserve of engineers is to be maintained in the field, organized in "auxiliary battalions," on a scale of about one per division. These are intended for the reinforcement of engineer units in any part of the field of operations and give considerable power of manœuvre to the engineer-in-chief. They differ mainly, it would seem, from the "general service regiments" mentioned above in the type of training received, *i.e.*, they are less specialized.

Special engineer units contemplated for war are "camouflage battalions," "railway operating and maintenance battalions," "topographical battalions," "bridge trains" and "dump truck trains."

The "combat regiment" of the Infantry Division is about 38 officers and 800 other ranks strong. It is organized into 2 battalions of 3 companies each, each of 2 platoons. There are thus 12 platoons (the smallest engineer unit) in the division. It is interesting to note that in the British Infantry Division there are also 12 of the smallest engineer unit, the section.

The "combat battalion mounted" of the Cavalry Division numbers 15 officers and 330 other ranks and is organized into 3 companies.

(B) Peace Employment of Engineer Officers.

Possibly the most interesting feature of the U.S. Corps of Engineers is the employment of its officers in peace.

The services of a large proportion of the officers are utilized in public works. Thus regular engineer officers are employed on the improvement of harbours and waterways, the construction of public buildings, parks, lighthouses and the survey of lakes, all in the home zone of the United States. In the past two years, the problem of the control of the Mississippi floods has been placed in the hands of army engineers. These are duties allotted in addition to the more normal ones of military engineers, such as road and other construction in the overseas American territories of Alaska, Panama, Hawaii and the Philippines. American military engineers built the Panama Canal and defences between 1903 and 1914, and military engineers are, according to the American press, now surveying the route for the proposed new canal through Nicaragua. In the performance of these extensive public works, the Corps of Engineers handles enormous sums of public money. Thus, for the year 1929–30, the budget for non-military activities, which consist in the main of public works administered by the engineers, amounted to over 25½ million pounds sterling.

The history of the attainment of their influential position with regard to the public works of the United States is also interesting.

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During the period of expansion of the United States westwards, the western areas reached at any particular stage were the scenes of constant wars with the Indians. These danger zones were controlled by the Army and all engineering in them consequently devolved upon the Army engineers. With the gradual move of the frontier westwards, the sway of the military engineer was extended until it ran right across the continent to the Pacific. The situation which developed then was not dissimilar to that existing in India in the days when Royal Engineer officers were responsible for nearly all the engineering in that country. It is remarkable in the case of the American Corps that they have to-day maintained their position as public works engineers in the face of keen civilian competition. That this is so is undoubtedly due to the fact that it is found cheaper to employ Army engineers and that the Engineer Corps hold an unblemished record in the administration of large sums of money over a very long period.

In the American Army, as in ours, the Signal Corps is separate from the Engineer Corps. The Engineer Corps, however, is responsible for survey, as in the British Service. The Army carries out survey of public works and is responsible for map-making in military zones. The military survey service, however, has no place comparable to ours as regards survey of non-military lands at home. There is no American analogy to the Ordnance Survey of England and Wales, and, in the sphere of survey, conditions are exactly the reverse of those in general engineering, in that civil survey predominates over military survey. A final point of difference between the British and American Corps is that, in the U.S.A., searchlights are worked by personnel of the Coast Artillery Corps and not by engineers.

(C) Training of the Corps of Engineers.

Officers for the " Corps of Engineers " are found mainly from the regular output of West Point. A few come in from civil life direct. West Point provides a strenuous test. The course lasts four years, and the curriculum includes many non-military subjects, for many of the cadets do not go into the Army at all. In consequence, young engineer officers receive a wide general education. They are subjected to severe discipline and the raw material entering the Corps is thoroughly prepared for the wide duties of the military engineer. At the same time, the syllabus contains a large proportion of engineering subjects, handed down from the time when West Point was primarily an engineering college. In fact, the college course is said to cover the same ground as the first three years of a university engineering course. Young officers receive their commissions considerably later than is our custom, for they mostly enter West Point

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between 19 and 21 and pass out between 23 and 25. The number of commissions given has been approximately 25 each year recently.

On leaving West Point, about half the young officers go direct to river and harbour duty (*i.e.*, public works) and half go to engineer regiments. After some three years, in which a portion of time with troops is essential, officers are sent off on purely technical civilian engineering courses, lasting about a year, at places of learning such as Institutes of Technology and Polytechnics and the Universities of Cornell and California. After this course, the officers return and go through a prolonged course at Fort Humphreys in Virginia, the engineer centre corresponding to the S.M.E., Chatham, where it is intended that the various forms of knowledge acquired in the previous four to five years shall be consolidated. After five to six years' service, officers leave Fort Humphreys. By that time they are expected to have made up their minds as to the type of work that suits them best and are variously allotted to public works, duty with regulars, or with the Organized Reserves and National Guard, at home or abroad, as required. With the greater proportion of their officers at home, the turn for foreign service does not come round very frequently.

A regimental institution exists similar to the Institution of R.E., under the title of the "Society of American Military Engineers," "dedicated to the National Defence," which produces an attractive and high-class journal containing many articles which would interest British engineer officers.

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A SUBALTERN IN THE INDIAN MUTINY.

Containing some letters of Lieutenant Edward Talbot Thackeray, Bengal Engineers, afterwards Colonel Sir E. T. Thackeray, V.C., K.C.B., R.E. (1836–1927).*

Edited by BREVET COLONEL C. B. THACKERAY, D.S.O. (*late Lieutenant-Colonel, R.A.*).

II.—DELHI (THE RIDGE).

The ancient fortress of the Moghuls stood on an almost flat plain, the River Jumna sweeping round one side of its walls. It was protected on the land side by a twenty-four-foot deep scarp and ditch, with bastions and fortified gateways. The only commanding ground was a low spur, running away to the north. The river was spanned by a bridge of boats, out of range of guns on this spur. Of the total perimeter of seven miles, little more than a mile of the northern face was "invested" by the force under General Barnard. The enemy were thus free to receive supplies and reinforcements, or to sally forth in battle array. It was not a siege, properly speaking, for the besiegers were, contrary to all the accepted canons of war, hopelessly outnumbered and under-gunned. The investing force was, in fact, itself in a state of semi-siege.

The strength of the attackers lay in their hold on the long, low Ridge, the hog-backed spur captured by Barnard on the 8th June, some two miles in length and sixty feet above the *terrain*. But only its southern extremity commanded the city, menacing the fortress like the point of a spear barring its northern front. Its left flank was partially protected by the River Jumna. Fortunately, thanks to lack of enterprise on the part of the enemy, communications with the Punjaub were never cut, though with Bengal and the capital, Calcutta, they were very precarious. Most of the Indian troops were armed with the old muzzle-loading Brown Bess. Consequently, much of the fighting was hand-to-hand, the last instance of its kind on a large scale and over a prolonged period in modern warfare. There were many fluctuations in the strength of the Field Force. Reinforcements dribbled in from outlying stations. In the earlier stages the total strength was about 3,000 British and Indians,

* These chapters are an abridgment of the first part of a future publication. Extracts from Sir E. Thackeray's *Two Indian Campaigns* (published in 1896 by the R.E. Institute), and other reminiscences, are distinguished by his initials, thus, [E.T.T.].

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with 22 field guns; at the assault it was roughly three times that number, with the addition of an inadequate siege train, and two to three thousand native irregular contingents; but this total included 3,000 sick and wounded. The strength of the enemy was never less than treble, and sometimes five or six to one, with a great preponderance of artillery, supported by masses of semi- or un-disciplined armed men.

The old cantonment on the Ridge, with its hutments, had been gutted by the mutineers. The British camp was pitched under cover of the Ridge, and clear of bombardment, but it lay exposed, and was frequently attacked on all sides. "The ground round Delhi, which was traversed by several canals and roads, was a tangled mass of old ruins, dense woodlands, rice fields, insalubrious swamps, and walled garden enclosures. It offered innumerable facilities to armed men of any degree of discipline, but the many combats of which it was the scene were rather trials of strength between small bodies than operations by masses." [E.T.T.]

For many weeks, hardly a day passed without the troops being turned out for some real or threatened attack, or to carry out some offensive operation. The rebels used our bugle calls, and their bands played British tunes. "Cheer, Boys, Cheer," was a favourite. The distant strains of music and the sounding of bugles and trumpets invariably heralded trouble, either the arrival of fresh reinforcements, or a forthcoming sortie. The latter took place three or four times a week, but always, says Thackeray, "with a uniformity of failure, of which it would be tedious to recite the details." The counter-attacks sometimes cost us two or three hundred killed and wounded. They were carried out with an *élan* that took them to within grape-shot of the rebel guns on the city walls, and stringent orders had to be issued against pursuing the enemy so far.

The heat and the torrential rains of the monsoon caused much suffering and disease. There were hundreds of deaths from sunstroke, and cholera, that most dread scourge, was always present. The air was tainted with corruption. Corpses of men and animals lay unburied in "No Man's Land," and the plague of flies was indescribable. Medical arrangements were perforce inadequate, and hardly a case of amputation survived. The daily casualties from sickness, and in the incessant fighting, amounted to forty or fifty a day. After a regular engagement they frequently ran into three figures. Our losses in killed and wounded alone during the three months' 'siege' were nearly 3,000, and the assault and capture cost another 1,400. Artillery ammunition supply gave cause for anxiety. At one period, in order to husband our resources, we were reduced to making use of the round shot fired at us by the enemy. Prices were fixed for the different calibres, and men and followers did a brisk trade in the retrieved ammunition. At first, the camp servants raced to pick up

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the round shot, as they rolled down the slopes. There were many burnt fingers, until they learnt that the prize was nearly red-hot.

One of the greatest anxieties arose from the danger of desertion or mutiny among the native troops on the Ridge. On at least one occasion, treachery at the picquets led to a daring incursion by rebel horsemen into the heart of the camp. Unfortunately for them, it chanced to be the lines of the superb Bengal Horse Artillery, and their redoubtable commander, Tombs, roused from his hard-earned slumbers, rushed from his tent, breathing fire and imprecations. A ding-dong *mêlée* ensued round the guns, in which Tombs and his subaltern, Hills-Johnes,* won their V.C.s.

Officers of the Engineers played an outstandingly conspicuous part in the siege, out of all proportion to their rank. Promotion was rapid, but at the outset all, except the Chief Engineer, were subalterns, the senior among them, Lieut. Alex Taylor, having fourteen years' service. Before Major Baird Smith joined, three enterprising and highly talented Engineer subalterns, headed by Wilberforce Greathed, were in the innermost councils of General Barnard. Without consulting his Chief Engineer, his Artillery Commander, or other senior officers, the General accepted the plans of assault drawn up by the three young officers, although no breach had been made in the walls. Orders were issued accordingly, but on more than one occasion an unforeseen hitch at the eleventh hour prevented the assaulting troops from taking action.

The prominence of the Engineers at Delhi was due to the peculiar staff arrangements of that period. The whole direction of siege operations was left in the hands of the Engineers, who were employed not merely as technical advisers, but performed for the time being the duties of a general staff. As the editor of Sir Archdale Wilson's Letters points out: "It seems incredible that the officer in supreme command should be compelled to resort to advice and requests in a matter affecting the general conduct of operations; but the custom of the service then ruled that no interference with the Engineers when engaged in their special work could be permitted."

Barnard's first Chief Engineer was an old Major, who arrived at the seat of war accompanied by his Persian wife, with twenty or thirty camels in her train, and half that number of carts. He was very soon placed on the sick list, and was succeeded, early in July, by Major Baird Smith, an experienced officer of forceful personality and the highest professional attainments. Baird Smith and Alex Taylor formed an admirable combination. The older man, handicapped by ill-health and a painful wound, played a statesmanlike and convincing part in the councils of the General, and used his pen and tongue with effect, whilst the junior was the man of action.

* Afterwards Major-General Sir H. Tombs, V.C., K.C.B., and General Sir J. Hills-Johnes, V.C., G.C.B.

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The conduct, not only of the siege proper, but of the assault and capture of the city depended largely upon the daring personal reconnaissances of Taylor and his subordinates. Baird Smith's penetrating brain moulded into shape the plans devised by Taylor, which the iron determination of the younger officer carried into execution. It is now generally agreed that the desperate schemes of the fire-eating Sapper subalterns stood little chance of success. Lord Roberts gives his opinion that, "the failure to give effect to the young Engineer officers' plan may be looked upon as a merciful dispensation of Providence, which saved us from what would most certainly have been an irreparable disaster."

The Delhi Field Force fretted at the delay, but they were exasperated by the taunts of speakers and scribblers, not only at home, but in India, who seemed to think that Delhi had no walls, nor men and guns behind them, or, if it had, that they would fall, like the walls of Jericho, at the blast of our bugles. All honour to the men who lost not a spark of their dauntless spirit, through those months of trial.

FOURTH LETTER (CONTINUED).

E.T.T. to his Aunt, Miss Henrietta Shakespear.

DELHI.
July 2nd.

. . . . Our batteries are on the top of the hill, about 1,300 yards from Delhi. Since the 8th we have been here now three weeks, making batteries on the hills and pounding away into the town, but I fear without much damage. The enemy come out about twice a week and skirmish. In fact, two or three of these sort of affairs have been regular battles and we have lost many men. On the 8th I felt rather strange, being under such a fire, but three weeks of it with eight hours every day in the battery accustoms you to it. I have had some wonderful escapes, as we have almost all, but the Engineer officers have been very fortunate, though we have lost about twenty men, killed and wounded, of the Sappers, which, considering our very small number, is very great . . . but I thank God for having preserved me in such good health.

We are very comfortable now, as we have taken possession of a nice house which once belonged to some unfortunate Europeans, who were murdered at the massacre here. They hardly left one house untouched. The place where we are is where our cantonments were. Fancy us leaving a place like Delhi with all our stores and guns in it, with nothing but native troops. Not a European regiment in it. I will not say anything about the General, etc., as you will, I hope, hear all about it in the paper.

Who do you think I met in the middle of the fight on the 8th,

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just after we had taken the heights—Robert Low.* He is orderly officer to General Barnard. His regiment has not yet mutinied, but I suppose will, as about thirty regiments have now. Sir T. Metcalfe† is in camp. His house which was a beautiful place, but now completely destroyed, is occupied by our picquets. Hundreds of the mutineers have been killed since we have been here, in the skirmishes which take place almost daily. I have some of the numbers of their regiments taken off their caps. They use our bugle calls and come out in red coats. Is it not a dreadful thing, fighting against, as it were, our own men whom we have educated and made soldiers and armed? They are fighting us with our own guns and everything.

We are a very jolly party and have a nice mess. You will perhaps like to hear, though I tell you of it, that the General Commanding thanked Champain and a party of Sappers and me for making a battery one night, and said we had used great exertion to finish it. . . . The Artillery have very hard work in the batteries. A man sits on the parapet; when he sees the flash from the enemy's batteries, he says "Down," and down we all bob beneath the parapet. The worst is getting up there, as the shot come crashing about in a most unpleasant way. There is a large house on the Ridge, called Hindu Rao's house. There was a dreadful shot came through it one day, when our men were asleep and killed one officer and seven men of the Ghurkas and wounded four. . . . I am sorry to say all Oude has gone, and the Gwalior contingent. They receive reinforcements every day in the city, but we have been doing so, too, and they say we shall be in Delhi before the week is over. We have had part of the 8th and 61st Queens come in this week, and two regiments of Sikhs. The Sikhs are all right and capital fellows. We have lost about twelve officers in the force, killed since the 8th. Our native Sappers that are left have behaved very well: two of them were hit by a shell close beside me, as we were going into the batteries. One poor fellow had his leg taken off, and died in an hour, and the other was severely wounded. I tied up his leg myself as there was no doctor. The men behave splendidly in all the regiments. A Carabineer was hit by a shot which took away his arm and leg. He said, "Oh, there goes my arm and leg. Give me a glass of water, please." . . . How thankful we ought to be that the Sappers did not mutiny before, when we were at Roorkee, as they might have killed us all. The China troops have, I believe, been stopped and are coming to reinforce us.

July 3rd. Last night we were all ready for the assault and very eager for it. Some of the Irregular Cavalry mutinied in camp and the General counter-ordered it, much to everybody's disgust. I am

* Thackeray's cousin, afterwards General Sir Robert Low, G.C.B., of Chitral.

† Sir Theophilus Metcalfe, Bart., C.B., married Robert Low's sister. He was magistrate of Delhi.

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afraid his policy is not much approved of. The Engineers had planned it and everything was ready. There were to be five storming parties, two Engineers' officers, Lieuts. Greathed and McNeill, and myself, with a party of Sappers, were to have led one party and blown in a grating with powder bags, through which the canal used to run into the city, but the water of which we have turned off. I have told you this, as I do not think it likely the plan of attack will be the same way. And now, my dear Aunt, I must come to the conclusion of this long epistle. I hope my next will be from inside Delhi, and hope God will spare me to see you all again at home. Depend upon it, everybody will do his best at the assault. I am afraid the last post has been robbed. . . . I am in excellent health and spirits. We have twenty-two Engineer officers now, Colonel Baird Smith commanding. I am afraid we shall not get medals for the campaign, as it is against Mutineers, but everybody thinks we deserve them.

* * * * * *

Hindu Rao's house, the key of the position, was held throughout by the incomparable Sirmoor Battalion of the Gurkha Regiment, under Major Charles Reid.* Neither he nor his gallant little hill-men ever left its vicinity, except to try conclusions with the mutineers. He himself never once visited the camp, until carried into it wounded on the day of the final assault. The Sammy House, within grape-shot of the bastions, was another of the most exposed points, on which night attacks were frequently made, a continuous roll of musketry being kept up all night. "I remember seeing the corpses of the mutineers after one of these attacks piled in heaps to a height of several feet. . . . The picquets at the Sabzi Mundi may, perhaps, be awarded the palm for the deadly nature of the combats which they sustained. Hand-to-hand encounters were of frequent occurrence. On one occasion, during one of these fights, a rebel Sepoy thrust his head through an opening of the wall. A Gurkha Sepoy below the wall seized him by the hair and chopped off his head with one blow of his *kukri*." [E.T.T.]

"A few days after the commencement of the siege," Thackeray relates, "I was ordered to take a party, consisting of about 100 unarmed coolies, a few native sappers, and three non-commissioned officers, and six elephants, to Metcalfe's house to destroy some walls, and to clear the ground around the picquet which was stationed at this spot. Metcalfe's house, which had been the residence of the Assistant Commissioner of Delhi, Sir Theophilus Metcalfe, who was present during the siege, was a large house surrounded by a beautiful park. It is situated on the right bank of the River Jumna, distant about a mile from the city. After the massacre of the Europeans at

* Afterwards General Sir C. Reid, G.C.B.

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Delhi, on the 12th May, the house had been gutted, the valuable library belonging to Sir Theophilus, and all the furniture and effects being plundered and destroyed by the mutineers. (They were said to be valued at £90,000.) Before starting for Metcalfe's house, I had explained to the serjeant in charge of the elephants that he should take the turning to the left, and we started as it was getting dusk. I rode at the head of the little detachment, and on arriving at the park gates, turned to the left with the sappers and coolies. After journeying some distance towards Metcalfe's house, I halted the party and galloped back to the gates. It was now dark, and I could see or hear nothing of the elephants. I then conjectured that the serjeant in charge must have tarried somewhat behind, and in the darkness must have failed to notice that we had turned to the left through the park gates, and, in fact, at that moment he must be quietly walking along the road with the six elephants towards the enemy's picquets at Ludlow Castle, about 300 yards distant. All this passed through my mind in much less time than it takes to write it. I turned my pony to the left, and galloped in the darkness in the direction of Ludlow Castle. I was only just in time. The serjeant was calmly walking along the road to destruction with the six elephants, with their *mahouts*, and some of the coolies. I touched him on the shoulder, and turned him round without speaking. The enemy's advance post at Ludlow Castle could not then have been more than 80 yards distant, but the night was very dark, and they heard no sound. We got back to the park, and arrived at Metcalfe's house in safety. Here we worked during the night, the elephants using their trunks to tear down trees and brushwood, and using their vast weight to push down the mud walls of the servants' houses, and other buildings, that were in too close proximity to the Commissioner's house. . . ." [E.T.T.]

On the morning of 5th July, Sir Henry Barnard, the Acting Commander-in-Chief, held a lengthy consultation with Colonel Baird Smith, the newly-arrived Chief Engineer, who was in favour of an immediate assault *de vive force*, as recommended by Alex Taylor. He reserved his final decision. Within an hour Barnard was struck down by cholera, and died that afternoon. The general feeling was that he was unequal to the great task before him. His complete ignorance of India led him to listen to the advice of every plausible talker. But whatever judgment may be passed on his generalship, he was a gallant commander and a most chivalrous gentleman, who won the hearts of all who served under him.

He was succeeded by Major-General T. Reed,* who, though he was Barnard's senior and provisional C.-in-C., had been prevented by sickness from assuming command previously. He only retained the command for twelve days, when he was compelled to retire invalided

* Afterwards General Sir T. Reed, G.C.B., 1796–1883.

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to the hills. Major-General Archdale Wilson, of the Bengal Artillery, who was never in good health, was appointed to the command, over the heads of other brigadiers. Lord Roberts speaks of the choice as the best under the circumstances. He was a conscientious officer of average ability, and a good administrator. Colonel Keith Young, the Judge Advocate General, a shrewd observer, described him as "rather over-careful," "wary," and "painstaking," "a gentlemanly, quiet, steady 'old fellow,' looks to everything himself, and gives clear and distinct orders." He greatly improved the discipline, comfort and general conditions of the troops.

Every account tells of the magnificent fighting spirit of the men, in spite of sickness, in face of tremendous odds, and under an Indian sun at its hottest. Their morale and mettle were beyond all praise; but, as will happen with the best fighting troops, their discipline was growing lax under the strain. Wilson ameliorated the hard lot of the camp followers, who though they did splendid work and suffered heavy casualties, were not always well treated by the men. Thackeray speaks thus of the coolies, who were enrolled as pioneers. "Strange to say, these men, who were at once transferred from the peaceful tasks of day-labourers to the most dangerous duties of working parties in siege operations, never exhibited a symptom of fear, but worked under the hottest fire like veterans, and were invaluable. The casualties among them were inevitably very numerous, but no instance occurred of their having hesitated to obey any order, whatever its consequences might have been." And again: "It may be remembered that the siege took place during the rainy season, so that the troops were continually drenched. The Engineer officers had to take parties of unarmed coolies out at dusk, to work between the Ridge and the city, their work usually consisting of felling trees and bushes, and clearing the ground in front of the picquets. Attacked by the enemy in the darkness and rain, it was really wonderful how patiently these poor coolies bore their sufferings, and their conduct was a matter of universal admiration." Lord Roberts also has a word of praise for them. During the first night of the construction of Major Scott's battery within 180 yards of the wall, "to arm which, heavy guns had to be dragged from the rear under a constant fire of musketry . . . 39 men were killed and wounded; but with rare courage the workmen continued their task. They were merely unarmed pioneers, and with that passive bravery, so characteristic of natives, as man after man was knocked over, they would stop a moment, weep a little over a fallen friend, place his body in a row along with the rest, and then work on as before." Thackeray mentions that thirteen were killed by one rocket ricochetting among the coolies. The *bheesties* (water-carriers) deserved the highest praise. Many of them were killed taking up water to the men in the firing line.

During July, Thackeray writes, "many of us suffered from

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dysentery, and cholera had now begun its dire work. All the troops suffered alike. The officers received a daily tot or ration of rum, like the men. Many of us carried a soda-water bottle, containing the rum ration, into the trenches, and I attribute having survived the exposure and wet at this time in a great measure to this cause." A letter to his brother about this time mentions that he was suffering from dysentery and skin disease. "I fancy it is from drinking bad water and partly from exposure." But he never missed a day's duty during the siege. "I have not received any pay now for five months," he says, and adds generously, if inconsequently, "so mind you take as much of what I have at home as you like," for an invalid sister, "as there is no occasion for it at Delhi."

One of the most important and dangerous works carried out by the Engineers from time to time was the destruction of bridges, for which purpose small columns were on several occasions sent out from camp, and fought many desperate engagements. "Attempts were also made to destroy the main bridge of boats across the Jumna, near the fort, by floating down rafts with infernal machines, but none of them were successful. On the rafts were barrels of gunpowder, to which pistols at full cock were attached, in such a manner that a sudden jar would discharge the pistol and ignite the gunpowder. We used to row the rafts out into mid-stream, and then abandon them to the stream. None of them, unfortunately, reached the bridge of boats." [E.T.T.] They stranded on sandbanks, where they ignominiously exploded, or were captured by the enemy. The Sappers came in for a good deal of chaff, as everyone not on duty was lined up on the Ridge to watch the fun. Sapper "stunts" were a standing joke in camp. At one time, mining operations on the part of the enemy were suspected at the Metcalfe stable picquet. A counter-shaft was sunk, and at first the sound grew louder. But the noise of our miners caused the enemy to abandon their design. Others said that the noises were susceptible of simpler explanations. This method was often used on later occasions: the officer stood waiting, revolver in hand, and as soon as the partition was broken down, charged through at the head of his men.

FIFTH LETTER.

ENGINEERS' CAMP
(before Delhi).
July 26th, 1857.

E.T.T. to his brother, F.St.J.T.

You see we are still here and not inside Delhi yet. I believe all our letters from England have been stopped or lost. At least, none of us have had any for about six weeks. It will be quite a new sensation getting a letter.

We are waiting still here for reinforcements and I believe they will soon be here. We could take Delhi, they say, any day, but have

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not enough men to hold it. The city is an immense place and when the troops get in the streets, we should lose a great many men, as the *pandies* (our name for the enemy) would be sure to retire there. They come out on an average about two or three times a week and attack us. We take it very coolly and invariably drive them back, they losing three or four hundred men every time, killed and wounded, and doing us very little harm. We are entrenching our position and are perfectly secure from their attacks. They say that the fate of India depends upon us meeting with no repulse at Delhi and the General (Wilson) is determined to wait till we have more troops.

When you come to think of it, our men have behaved wonderfully well. We have been here for nearly seven weeks, with a force of from two to three thousand men and had to repulse an enemy of ten to twelve thousand men. Twenty-four times have they come out. I have seen them myself often through my glass, filing out of the city, cavalry, artillery and infantry, taking an hour to come out. They have tried every point of our position, right, left and centre, and invariably with the same result. Our men have waited for them, till they came as near as they could, which is never very near, and then gone at them. The ground is most favourable for them between this and Delhi, being nothing but trees and rocks. They get behind these and pick off our men. It is a very savage kind of warfare.

I have a very bad piece of news to give you, and I am sure you will be sorry to hear it. Poor Jones, one of my oldest and best friends, who came out with me and who I have been with for nearly five years, is dead. He was out with a working party making a breast-work when the enemy brought some guns outside the city. The first shot they fired, a six-pounder, went through his left leg and carried away the calf of his right leg. His left leg was amputated immediately and he was doing very well for two days. I was with him in the afternoon the day it happened. He said he felt no pain and was talking to me in very good spirits. On the third day afterwards, fever seized him and he died on the fourth day. . . He is a great loss to us all. I can hardly believe he is dead. Don't you remember our dinner at Southampton? Poor Jones and his brother, you and I. I little thought then he would so soon be gone. . . . I cannot realize his death at all, I have known him so long.

We have suffered very heavily (I mean the Engineers). One officer, Walker, died of cholera. Captain Greensill, H.M. 24th, who was attached to our Corps, was shot dead by one of our own men at night, who mistook him for an enemy, and now poor Jones. His effects are to be sold to-night. He had brought out a most beautiful outfit with him of guns, rifles, etc. As for our men, we left Roorkee with 45 European Sappers, N.C. officers, and 10 have died of cholera alone in the six weeks here, 1 killed and 4 or 5 wounded, so we have

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hardly any fit for duty. Carnegie was slightly wounded by a musket ball in the arm, but is well now. I have been, thank God, most fortunate. I am in excellent health and have been under heavy fire three or four days out of every week and have never been touched. Walker, of the Bombay Engineers, has been badly wounded, and Geneste, of ours, slightly. Poor Innes, of our Engineers, who came out in the ship with me and Jones, has been killed at Allahabad, and I believe several other Engineer officers.

The *pandies* are beginning to find out their mistake. There is no doubt that the King of Delhi, the King of Oudh,* and others, have been for a long time stirring up the native regiments and told them that we wanted to force them to be Christians. The Mussulmen are in a great measure at the bottom of it. They thought that there were so few Europeans in India that they could kill us all at the same time, but at Meerut and Delhi they broke out too soon. They never thought we could get our troops together as we have. Out of 74 native regiments about 6 have remained staunch. The rest have either mutinied or been disbanded. At Agra, the Europeans have had to retire into the fort. At Cawnpore, Sir Hugh Wheeler, after holding out for three weeks with 100 men against three or four native regiments, was obliged to capitulate, having no ammunition left. The brutes allowed them to get into boats, and then killed them by firing at the boats. Two or three, I believe, escaped, Sir H. Wheeler among them.†

We have, I believe, now, all the China Expedition at Calcutta, and our turn is coming. We have the Gurkhas and Sikhs Regiments with us, splendid fellows, like Europeans. It enrages us to hear people at home in the papers talking of the mild and pious Hindu. If they had seen and heard some of their atrocities out here that we have had, they could not say so. Our men prefer shooting themselves to be taken prisoners by them. I hope this will let Government and John Company see what it is to have placed Delhi in the hands of native regiments, and to have been so sparing of having Europeans out here. . . .

The rains are going on now. Sometimes we are out in the rain twelve or twenty hours at one time. . . . Robert Low is in camp. He dined with me the other day. His regiment, the 9th Cavalry, has mutinied. The loss of officers in the campaign and massacres previously has been very great. We get all the news from England all right, but no letters. I shall, as you may imagine, and all will, be very glad when the reinforcements come and we all get into Delhi.

* Neither of these titular sovereigns was proved to have conspired against British rule previous to the Mutiny. The King of Delhi was found guilty of *subsequent* crimes, and deported. The King of Oudh was not tried.

† The whole garrison, with the women and children and wounded, were eventually massacred, except four—Lieuts. Delafosse and Mowbray Thomson, Private Murphy and Gunner Sullivan—who succeeded in escaping. The European garrison numbered 410, not more than half of them trained soldiers, with about 100 loyal Indians. There were in all 376 women and children.

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Poor Jones met a soldier's death, but I cannot help feeling his loss. Remember me to Mr. Hood and Wm. Thackeray. Thank him for the revolver. I wish I could see your new rooms at Lincoln. We are very well off here, as we have a bungalow to live in. . . . Good-bye and God bless you. . . .

[Later] . . . . We have twenty-five Engineer officers here now and are very lucky in having a house. From the deaths of so many of our officers (two were killed at Cawnpore and several others), I have had about ten steps in the corps since I have been out here. I hope you wrote for me to poor Jones' brother.

The Sapper mess was in one of the bungalows left standing in the cantonment outside Delhi, where the camp was situated, behind the Ridge. The officers' tents were pitched round it. The central room was occupied by a billiard table on which at first some of them slept. Then it was converted into a dining table, at which twenty or more sat down. Miss Taylor, in the Life of her Father, General Sir Alex Taylor, gives a lively picture of the mess, which never lost its good spirits.* Colonel Baird Smith, the Chief Engineer, who had wretched health, seldom dined there. His next senior and right-hand man, Captain Alex Taylor, otherwise "Musha," aged thirty-one, was the oldest in mess, the others being subalterns, some with over twelve years' service. There were in all thirty-two. Next came the witty and versatile Wilberforce Greathed, who, after his brief spell as

* It may be of interest to record the subsequent ranks and some of the services of the thirty-two members of the Sapper Mess on the Ridge at Delhi. Many of them served with distinction in other campaigns, not here recorded.

Generals and Colonels Commandant, R.E.:—Sir A. Taylor, G.C.B., President, Indian Defence Committee; President, Cooper's Hill College.—Sir F. R. Maunsell, K.C.B., and Sir Aeneas Perkins, K.C.B., both C.R.E.s in the Second Afghan War.—Sir G. Chesney, K.C.B., C.S.I., C.I.E., *M.P.* for Oxford; Military Member of Viceroy's Council; President, Cooper's Hill College; a brilliant political and military author.—General J. Walker, C.B., F.R.S. (Bombay Engineers), Surveyor General of India.

Lieutenant-Generals:—H. W. Gulliver.—C. T. Stewart.—J. Tennant, C.I.E., F.R.S. —H. R. Brownlow.

Major-Generals:—W. W. Greathed, C.B. After very distinguished military services, was head of the Irrigation Department of India.—W. E. Warrand.—Julius Medley.—C. S. Thomason.—R. S. B. Pemberton, C.S.I., Director of Railways; Member Viceroy's Council.

Colonels:—R. Baird Smith, C.B., *A.D.C.* Shared with John Nicholson and Alex Taylor the chief credit for the capture of Delhi. Became Master of the Mint. Died 1861.—A. Lang.—Sir John Bateman-Champain, K.C.M.G., Director of Indo-European Telegraphs. D. Ward.—Sir E. T. Thackeray, V.C., K.C.B. (civil), C.B. (military). Chief Commissioner, St. John Ambulance Brigade, was mentioned in dispatches for services in Italy during the Great War. Died, 1927, *æt.* 91—the last survivor.

Lieutenant-Colonels:—J. Laughton. Was Chief Engineer, Delhi Field Force, until invalided and relieved by Major Baird Smith.—T. Hovenden.

Major:—P. Murray.

Captain:—Greensill, H.M. 24th Regt. (attached), killed at Delhi.

Lieutenants:—Killed or died of wounds.—D. C. Home, V.C., and P. Salkeld, V.C. Both died within a month of winning the V.C. at the Kashmir Gate, Salkeld of wounds received, and Home by the accidental explosion of a mine.—F. L. Tandy.—E. Jones. Died during the Mutiny:—M. S. Geneste.—W. Fulford.—E. Walker.

Retired soon after the Mutiny:—A. McNeill.—H. A. L. Carnegie.

Of the 32, 8 were killed or died during the Mutiny, and 12 were wounded. This record takes no account of officers of the Corps in other parts of India.

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General Barnard's unofficial adviser, became a mere extra A.D.C. to General Wilson. He was commonly known as the "Insulting Engineer," the native corruption for Government Consulting Engineer. Frederick Maunsell, *preux chevalier*, Adjutant and then Commandant of the Sappers and Miners, the remnants of which he had helped to save from mutiny at Meerut; James Tennant, mathematician and astronomer, known as the "Objector General"; George Chesney, Brigade Major, the perfect Staff Officer, a man of brilliant parts; Henry Brownlow, with his caustic humour; Geneste, gallant, idle and capable, the actor and linguist of the Corps; Philip Salkeld, one of the party of twelve, including ladies, who escaped from Delhi by letting themselves down with sheets over the ramparts, and made their way to Meerut after a week of amazing adventures. He, with another Sapper, Duncan Home, led the little band of heroes who blew in the Kashmir Gate. Both were subsequently killed. There was Arthur Lang, who, as all agreed, earned many Victoria Crosses, though he was never awarded the decoration; and there were Fulford, who died, Tandy and young Ned Jones, who were killed; Gulliver, Hovenden and Warrand; "Jules" Medley, Thomason, the two Walkers, James (Bombay) and Edmund, who died of cholera. Captain Greensill, H.M. 24th Regt. (attached), was accidentally shot. They were as gallant and capable a brotherhood as ever sat round a camp table, and Lord Canning only voiced the general opinion when he spoke of the Bengal Engineers as "accomplished all-round men, every one of them, of clear intellect and cool courage."

From Sir A. Taylor's *Life* we learn that "the youngest of them was Edward Talbot Thackeray, a lad of twenty .... who was immediately dubbed 'My Lord,'" one of his Addiscombe nicknames. In amusing contrast was his friend, Charles Thomason, an eccentric and lovable Highlander, called 'Robinson Crusoe,' from the bizarre clothes which he affected, even in times of peace, their design and manufacture being left to his servants. He had a theory about heat rays, and covered his person with a patchwork arrangement of green cloth, soon mottled yellow by the sun. This "was anathema to 'my Lord,' who considered it a disgrace to his corps, and proposed that a subscription should be raised to give Robinson Crusoe a more conventional outfit. Robinson Crusoe himself enjoyed the joke, smiled indulgently and continued to protect his spine scientifically." It was not long before 'Lord Tall Boot,' in common with every other officer in the Force, was himself in a state of rags. "We were glad," he wrote, "to purchase articles of clothing or uniform of any kind at the sale of the effects of officers who had been killed or died."

There were few amusements on the Ridge, for every man was constantly on duty, but, as the weeks passed, recreations were

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organized, cricket and pony races. For those not actively engaged, cards were a means of whiling away the long hours at night in the batteries and trenches. Thackeray was fond of telling a story, which had been the round of the messes at Delhi, anent a certain very imperturbable officer. He and another were playing *écarté*, when a round shot crashed in upon them, taking off his opponent's head. He picked himself up, his eye-glass still firmly fixed, and piously ejaculating, in the words of a romantic poem, "Oh, Pilot, 'tis a fearful night," swept up the pack of cards, together with all the loose cash, and betook himself elsewhere. Gambling on a considerable scale went on after Delhi and Lucknow, when arrears of pay had been received and money was plentiful. Some of the less scrupulous were laden with loot. A young sapper officer, who rarely played, was induced to take a hand at Loo, a favourite game at that time. He had no loot and little ready money. So he staked his Engineer's allowances, month by month in advance, up to the rank of Major, that is, if he should escape the rebel bullets and reach that exalted rank. He lost. The winner, who was a V.C., a distinguished officer in another corps, drew this convenient allowance, amounting to several hundred pounds, for a great many years. One wonders whether, towards the end, he had any qualms about it.

There was no serious difficulty in keeping communications open with the outside world, to the north and west, by runners and pony *dâk* (mail). But Oudh, Bengal and Calcutta were cut off. It was weeks before authentic news came about Cawnpore and Lucknow. Secret dispatches were often written in French, Latin or Greek, or a combination of the three—which speaks well for the classical training of the public schools. Officers managed to write daily to their wives in the hills, and the wives to send them creature comforts. The Judge Advocate General, for instance, every now and then asks his better half to send him down half a dozen of port wine, and a couple of bottles of curaçao, or some cherry brandy and apricot jelly. Parsee merchants did a roaring trade. The bazaar was "crowded with people from the villages, with everything for sale in the greatest profusion." The Artillery Mess was famous for its beer, which fetched four or five rupees (at that time eight or ten shillings) a bottle, and brandy twenty rupees. Their *chef* was a *cordon bleu*, a magician, like all Indian *khansamahs*, who never failed, under the most adverse conditions, to produce six-course dinners, and "about the best gram-fed mutton and pastry in India." But this is only one side of a picture, in which heat and dust and rain and sickness predominated, to the accompaniment of cannonade and musketry fire, alarms and excursions.

(*To be continued.*)

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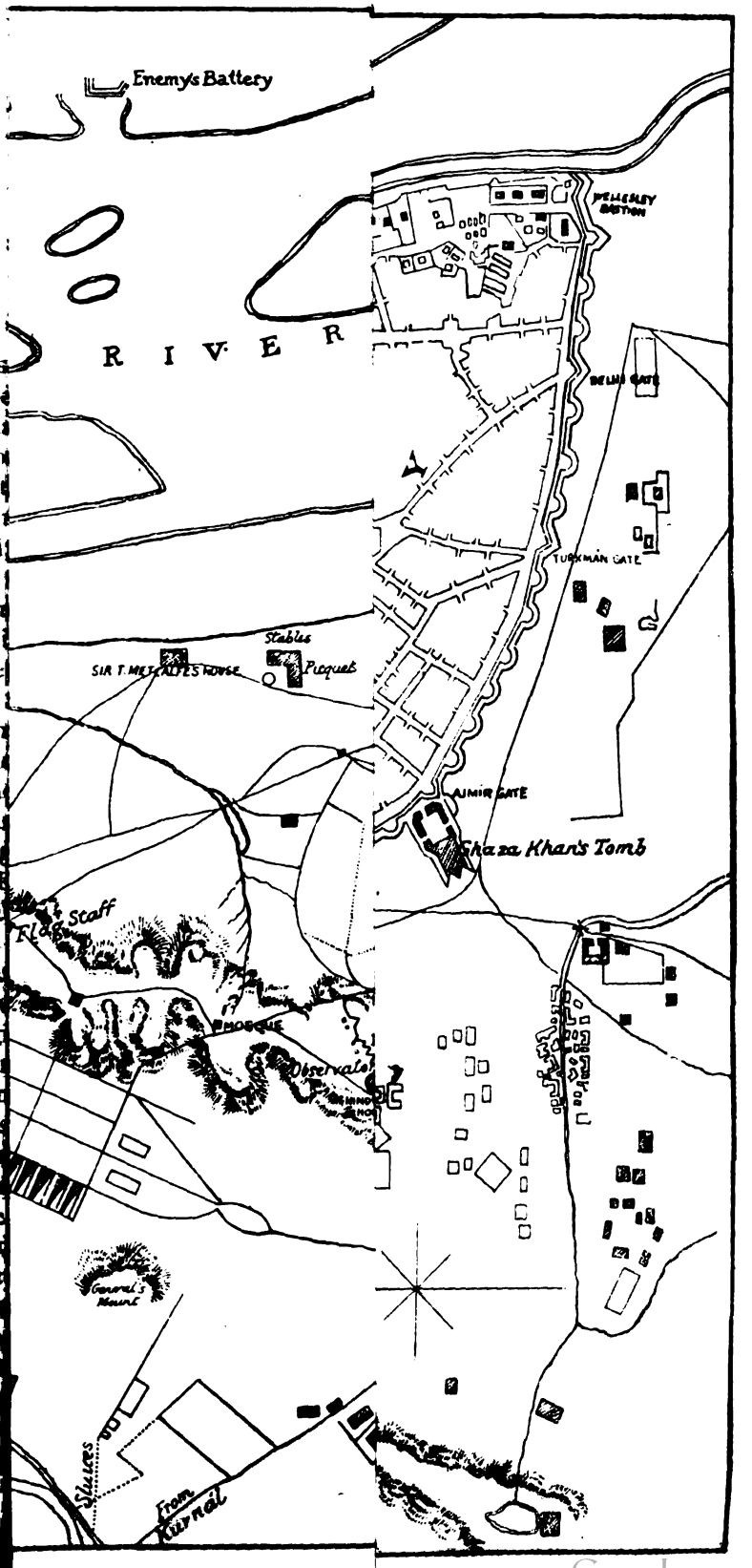

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THE KELANTAN SECTION OF THE EAST COAST RAILWAY, F.M.S.R.

By LIEUT. LL. WANSBROUGH-JONES, R.E.

THE East Coast branch of the F.M.S. Railways is being constructed purely as a development line to open up the states of Pahang and Kelantan, which are known to have rich mineral and agricultural resources. The line, which is metre-gauge, runs roughly north and south along the 102° meridian from Gemas on the Johore-Negri Sembilan boundary to Tumpat near the mouth of the Kelantan river, and the total length is about 327 miles. The survey for the line was started in 1909 and completed in 1915. Construction was begun at Gemas in 1907, and on the Pahang section in 1912; it was suspended during the War, but was recommenced in 1919, together with a short stretch in Kelantan from Tumpat to Sungei Golok and Kuala Krai. By 1921, when work was again stopped, the line had been completed from Gemas to Chigar Perah in the south and from Tumpat to Sungei Golok (where it joins the Royal Siamese Railway) in the north. When work was started afresh in 1924, there remained the partially constructed lengths from Tanah Merah to Kuala Krai and from Chigar Perah to Merapoh to be finished, and the stretch from Merapoh to Kuala Krai, on which no work had yet been done.

The latter stretch, which forms the subject of this article, is by far the most difficult section of the whole line; and has involved very heavy earthwork and tunnel construction, in addition to bridge and culvert work under the most varied conditions imaginable. The engineering problems encountered have been complicated by the extremely broken nature of the country and the liability to damage from flood, with the result that the stretch in question is probably the most vulnerable section of line in the whole F.M.S. Railway system. During 1924, work was started north of Chigar Perah and, on the completion of the Guillemard bridge over the Kelantan river, the line from Tanah Merah to Kuala Krai was opened to traffic. Eight bridges were constructed during the year, and Hume pipe works were installed at Chigar Perah and Kuala Krai, the latter being moved later to Kemubu. Slow progress was made in 1925, owing to very heavy earthwork and a considerable number of stream diversions, but five bridges were erected and two tunnels practically completed. The tunnels presented more difficulty than was anticipated, owing to the varying nature of the ground through which they were driven. The presence of large pockets of shale and loam in the limestone hills

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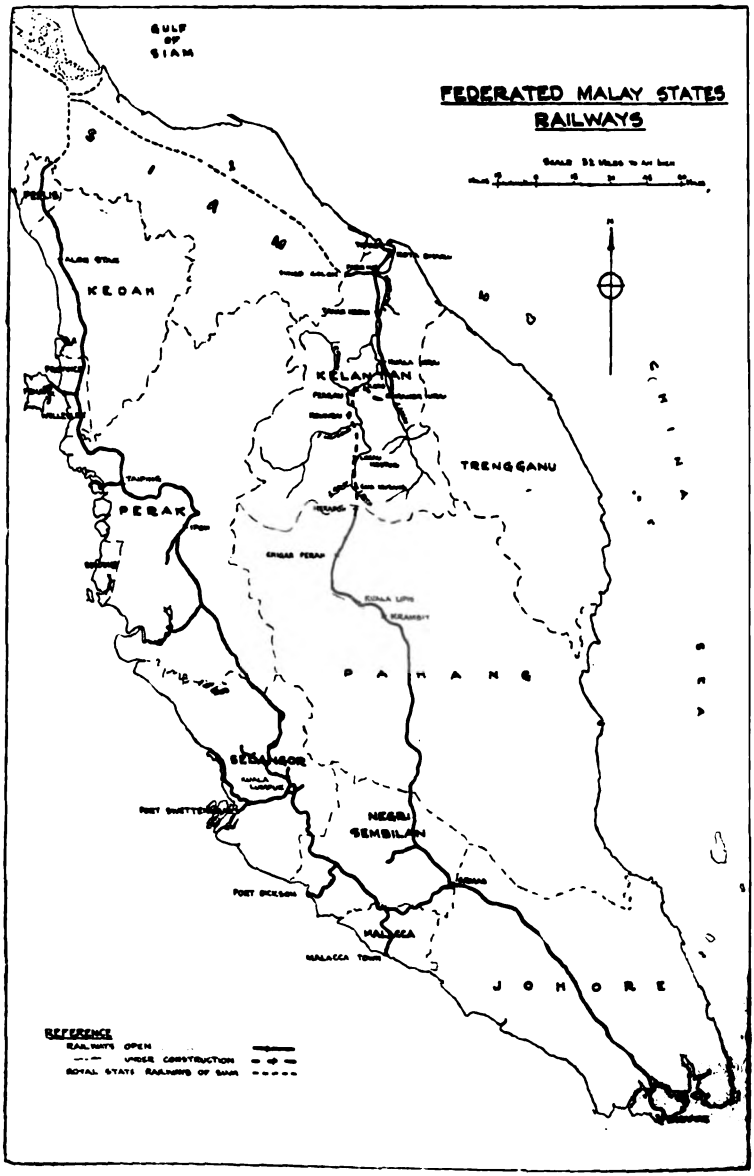
caused frequent slips in the headings, particularly in Tunnel No. 4, where one face eventually had to be closed down, as slips and flooding from underground streams made it unworkable. Towards the end



of the year, the earthwork suffered heavily from monsoon rains, and difficulty was experienced in obtaining labour to restore the formation as, with the development of the country, coolies were attracted to the new rubber estates.

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By the middle of 1926, two more tunnels had been finished, and by December the headings had been driven in three more and well advanced in two others. Five bridges had been completed, and the section from Chigar Perah to Merapoh was ready to be opened to traffic; also certain lengths had been re-surveyed and a new alignment had been adopted near Kemubu, which cut out two tunnels. At the end of the year there occurred the most disastrous floods yet known in Malaya, affecting particularly the states of Kelantan and Pahang, where the greater part of the year's work was obliterated and the entire length of the East Coast Railway disorganized. Between the 15th and 20th of December, 1926, there was heavy rain all over Kelantan and Pahang, but not enough to cause any abnormal rise in the rivers. From the 20th to the 29th, however, it was practically incessant, and at one station in Kelantan, where the rainfall recorded for the month was 62·45 inches, nearly 45 inches fell during these last ten days. The rivers rose above their normal flood levels on the 23rd, and continued to rise at the rate of some six inches an hour until the 30th, when the floods began to subside, but the water in the rivers did not drop to the normal flood levels until about January 5th, 1927.

On the 29th, 30th and 31st the situation along the whole line became very serious. The construction camps at Kuala Krai, Manek Urai, Pergau, Kemubu, Nipis, Gua Musang and Chigar Perah were all wholly or partially destroyed, and all stores and records lost or irreparably damaged. During these three days the rivers were about thirty feet above their normal flood levels, the maximum recorded rise being at Bertam, where the Nenggiri River rose over seventy feet. Flood velocities of eleven and fourteen feet per second were recorded in the Galas and Ketil rivers respectively. Extremely severe conditions were experienced in the construction camps during this period, as all nationalities were eventually driven to refuge in the few buildings that remained in the highest parts of the camps, and the numbers were everywhere increased by parties of refugee Malays who came down from the head waters of the rivers for food and shelter.

The conditions at Chigar Perah are quoted as being typical of those prevailing all along the line. There all the buildings were destroyed with the exception of a small office measuring about twenty feet by thirty-five feet, in and under which were collected six Europeans, including two ladies, and over two hundred coolies of different nationalities and sexes, for a matter of nine days, with no communication with the outside world. Communication between camps, which was maintained by river and along the formation during construction, became impossible during the flood, as both these means disappeared, the one being unnavigable and the other under fifteen to twenty feet of water. The camps were thus completely isolated,

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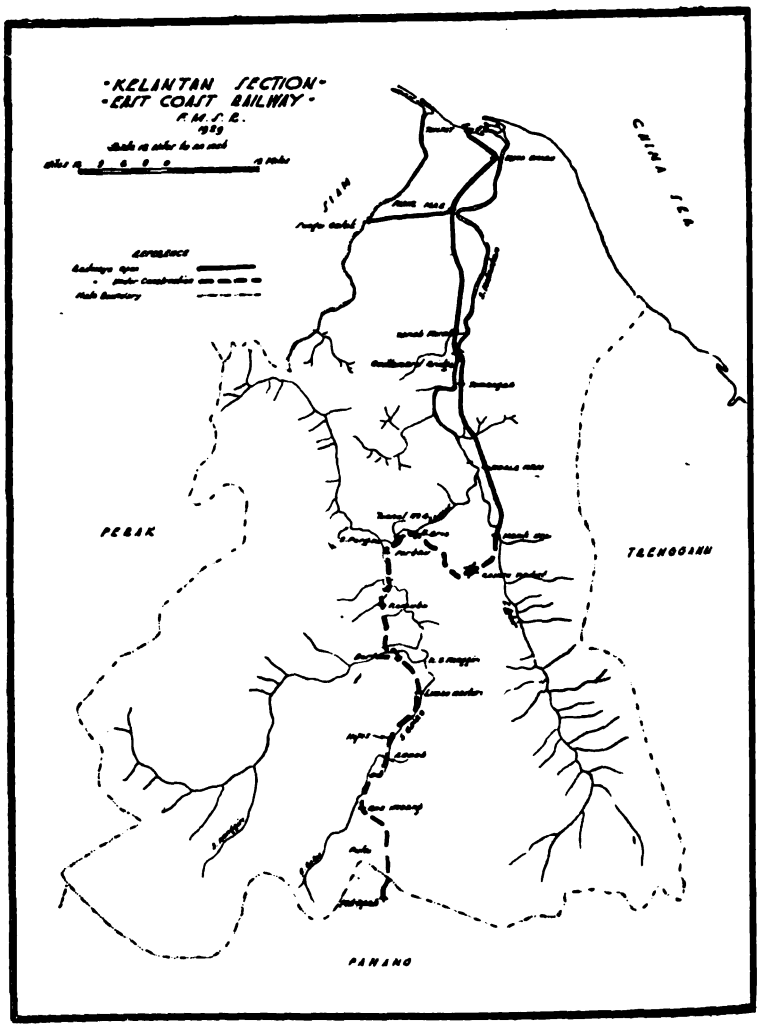
and the construction staffs and coolies were subjected to severe privations; food shortages occurred at most points, and systems of rationing had to be introduced. A very noticeable feature throughout the flood was the attitude of the Chinese and Tamils who formed the greater part of the coolie gangs; these men made little effort to



assist in saving food and necessities until it was too late, and preferred to sit down in apathy and terror and watch their shelters and belongings washed away and broken up in the streams. Great energy was shown by Sikhs and Malays, and many lives were saved and much material salved through their agency; the Malays particularly showed much enterprise in building "rakits" (bamboo rafts) for distributing food and restoring communications.

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The year 1927, which should have seen the sections Kuala Krai–Manek Urai and Chigar Perah–Merapoh opened to traffic, had to be spent almost entirely on reconstruction. At the time of the flood the activities of the Construction Department extended over a hundred and twelve miles from Kuala Krai to Chigar Perah, and throughout this length the camps had virtually disappeared, the yards and buildings that remained being left everywhere under about two feet of silt ; nearly all the rolling stock was lost and damaged, and the formation completely destroyed in many places. The most serious damage of all was done at Manek Urai, where two two hundred and fifty-foot spans of the bridge over the Lebir River were carried away. To the north and south of this stretch, sections which had been handed over to the Open Lines Department were so badly damaged that they had to be restored to the Construction Department for repair ; the worst of these was the Sungei Golok line, where two spans of a hundred and fifty feet, two of sixty feet, and one of forty feet were destroyed and huge gaps made in the formation. The total loss through the damage and disorganization caused by the flood on construction works was estimated at $3,000,000* in Kelantan and $300,000 in Pahang ; the total loss of life was never accurately determined, but the Constructional Staff lost one European and thirteen Asiatics.

To cope with the enormous work of reconstruction on Open Lines, the whole of the Construction Staff in the south was transferred to the section between Krambit and Kuala Lipis, and by June 1st the line had been sufficiently restored to allow a restricted service. In the north, the situation was so bad that the Engineer-in-Charge decided to abandon the headquarters at Pergau and the section of line between there and Manek Urai, and base everything on Kuala Krai, from which point the work of reconstruction was extended north and south ; a course which was dictated largely by the immense damage to buildings and stores and the lack of food and transport. The flood was obviously an abnormal one, and unlikely to occur again, and work was so far advanced that it was not feasible to re-locate it at a higher level, so that in one or two places only, where the local conditions made it possible, were the formation levels altered ; notably at Manek Urai, where the bridge abutments were raised four feet, and to the south of Kuala Gris. Here the line, which runs through a deep gorge alongside the Galas River, had been completely obliterated, and a safer trace was located higher up, the new alignment involving four extra tunnels. At Manek Urai bridge the water was five feet above the top booms of the two hundred and fifty-foot girders (they are compression bowstring trusses twenty-three feet high at the centre) when the spans carried away ; the smaller hundred-

* The value of the Singapore dollar is 2s. 4d.

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foot spans at the south end of the bridge remained intact, and it was established that the failure was due to the enormous pressure of timber which had drifted down from clearings upstream, and had become knotted together by bamboos into a tangled mass that defied all attempts at clearing. Little damage was done to the piers and abutments, but as the girders were badly twisted, and one had been carried some way downstream, it was decided that it would be cheaper to break up the wrecked spans where they lay and put in new ones than attempt to salve them; a policy that was amply justified later on, despite the fact that there was only one two hundred and fifty-foot span available in the country at the time. On the whole the Hume pipe culverts stood up very well to their work, but in a great many cases the wing walls were scoured away and collapsed. Settlement of the tunnel walls accounted for the occurrence of several cracks in the linings, and in one case the hill through which the tunnel was being driven slipped bodily and caused a certain amount of internal damage; the work on the tunnel section was not, however, seriously impeded, and the damage was made good without much trouble. By the end of February, 1927, ballast trains had been run from Tumpat to Sungei Golok and from Kuala Krai to Manek Urai, and the latter section was handed over to the Open Lines Department in the middle of October, by which time the line from Pasir Mas to Kuala Krai had been repaired. A temporary bridge was completed at Manek Urai by June 19th, but progress south of that point was slow owing to lack of transport. The difficulties of reconstruction were enhanced by sickness which broke out immediately after the flood, and by lack of coolies, many of whom left as soon as the water had subsided, and did not return until "open lines" had been restored.

By 1928, re-organization was complete, and reconstruction well in hand; the end of the year saw the erection of twelve bridges and the completion of one tunnel, four other bridges were in various stages of construction and the earthwork had been practically restored throughout. Apart from the tunnels, which are mostly between Manek Urai and Pergau, the chief works in hand for 1929 were the erection of Renoh Bridge and the Kasuku Viaduct, and the handing over of the section Merapoh–Gua Musang to open lines; after the events of the winter of 1926, however, some apprehension existed as to the effect of the monsoon, and it was questionable whether the section ought not to be left in the hands of the Construction Department until the spring of 1930. In October, the viaduct had been completed and the falsework was being dismantled, but unforeseen delays had occurred at Renoh*, and the situation there was rather a critical one, as the temporary bridge, which was only about twelve feet above

* The erection of the girders was successfully accomplished before the monsoon broke.

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normal river level, was almost certain to be lost in the December rains, and there remained only six weeks in which to erect two two hundred and fifty-foot spans and clear the waterway of the falsework below them.

Practically all the bridges on the line have been erected on timber stagings or sleeper cribs built up between the piers to the level of the bottom booms, but one or two of the smaller spans have been launched complete. The falsework and temporary bridges across dry gaps are made of jungle timber cut on the site, but this wood cannot be relied upon to give more than six months' service, as it is not only soft and full of sap, but is also very prone to the attacks of white ants. The Chinese have become very adept at the working and handling of jungle timber, and a gang of twelve can frame up and erect a trestle twenty feet high, from round baulks roughly hewn, in an eight-hour day. Over waterways, or at points where the ground is at all soft, the falsework is generally built on to square hardwood piles (10″ x 10″ or 12″ x 12″) driven to about a quarter of an inch set, for which work Sykes' quick-action piling winches and McKiernan-Terry No. 6 hammers have been used, and have given very good service under the most exacting conditions. The trestles for temporary bridges are usually built with square hardwood transoms and ledgers, and are spaced at fifteen-foot centres, an axle load of twelve tons being carried across this span either by three clusters each of five 60-lb. F.B. rails or by three 14″ x 14″ hardwood stringers. The average cost of jungle timber falsework has worked out at about $25 per foot run of gap, and the enormous economy effected by the use of round baulks can be judged from the fact that the approximate prices per ton for round and square timbers of the sizes mentioned are $15.00 and $55.00 respectively.

Sleeper cribs filled with broken stone are now placed on the upstream sides of the trestles in temporary bridges to minimize the risk of damage from flood; they have not a chance as yet of proving their worth, but though in a small spate they may prevent damage from scour and floating timber, it is doubtful if they would have any real effect in a serious flood. In an attempt to prevent a repetition of the disaster at Manek Urai, the experiment is being tried of tying down the ends of the large spans of permanent bridges on their upstream sides by means of three-inch steel rods attached to the bottom booms, and to pairs of 6″ x 3″ R.S.J.s let into the piers or abutments about fifteen feet below the level of the bedplates. The rods are divided in the centre, and are fitted with right and left-hand screw threads so that they can be tensioned up after fixing. This arrangement has not yet had, and it is naturally hoped will not be given, an opportunity of proving its efficacy.

The F.M.S. Railways have standardized a series of spans both for deck and through bridges, and all gaps are crossed with

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combinations of these spans. The standard spans now in use are as follows:

Deck spans, 20, 30, 40, 60, 80, 100 feet,

Through spans, 20, 30, 40, 60, 100, 150, 200, 250 feet,

and of these all but the two longest through spans, which are bowstring trusses, have parallel booms.

The design of the footings for the piers and abutments is naturally determined by the local conditions. As a general rule, open foundations are put down if the soil is reasonably good and the excavated depth below ground level does not exceed twenty feet, but where there is any possibility of scour or a suitable bearing stratum lies only at a considerable depth, the load is taken on concrete wells sunk in pairs about six feet apart. These wells are concrete cylinders varying in external diameter from twelve feet to eighteen feet and in thickness from eighteen inches to three feet six inches, the dimensions depending on the span the foundations are supporting. They are built up in sections five feet long and are sunk under their own weight by dredging, the sections being bonded together by half-inch rods placed at one-foot centres concentric with the well and about one foot in from its external face. The first section, which is ten feet long, is sunk in a pit dug by hand and is built on to a steel or concrete curb having a cutting edge the same diameter as the well; the excavation is continued by grab and steam winch, and subsequent sections are cast on as the well sinks until it has reached a depth at which trial borings have revealed the presence of a suitable stratum, when the bottom is examined by a diver and, if satisfactory, is cleaned up and sealed with five or six feet of mass concrete. The two wells are then filled up to the top with sand and joined together by a reinforced concrete slab upon which are erected the abutments or piers, as the case may be. The usual rate of progress, including all operations, for such a well is about two feet in three days under normal conditions. There is a possibility that, when wells are driven through a soft stratum towards a hard one some way below, they may take charge and sink out of sight. A case somewhat like this occurred on the Sungei Golok line, where trial borings had revealed a suitable stratum about fifty feet down. This, however, proved to be very thin and, although it did not actually take charge, the well drove straight through it into a layer of soft shale and showed no inclination to slow up, sinking more and more under the weight of additional sections until excavation was discontinued at a depth of about seventy feet. In this case the well was not sealed, but was filled with sand, which mushroomed out at the bottom and consolidated the soft stratum until no settlement was discernible. Test loads were then applied, first to the sand core and then to the concrete shell to assist consolidation, and as no further settlement took place, the foundations were considered safe. The bridge has now been open to traffic for

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more than two years, and there has been no sign of movement in the foundations.

The East Coast Railway has been built to unusually high standards for a development line, and it is doubtful if the limitations of four degrees of curvature and a ruling gradient of one in a hundred are really justified. A little more latitude in these standards to, say, five degrees of curvature and one in seventy gradients would have resulted in a much more economical trace, particularly in the Kelantan section. It is unlikely that the line, which is due to be completed in 1931, will pay any interest on capital expenditure for another fifteen years, but the resources of the country through which it is being built are so great that there is little doubt that, once they are developed, the policy of the F.M.S. Railways in constructing a line up the East Coast of Malaya will be amply justified.

The state of Kelantan consists of a fertile and densely populated coastal plain about a thousand square miles in area, lying behind a low sandy coast line about sixty miles long; to the south of the plain the country is hilly and broken, the main hills being those of the main range of the Peninsula, which forms the boundary between Kelantan and Perak, and the Tahan range on the Pahang border. Many of the peaks in these two ranges are over six thousand feet high. This part of the state is thinly populated, and has, until recently, remained almost inaccessible, owing to the difficulties of river navigation and the complete absence of other means of communication; it contains the greater part of the foreign-owned estates, however, and is now being opened to settlers by the East Coast Railway.

The climate of Kelantan is probably better suited to Europeans than that of any other part of Malaya, it is dry, cooler than Kedah and Perak and may almost be described as bracing. The country has many attractions. Unspoiled and undeveloped by Chinese immigration, it still possesses all the original characteristics of Malaya, and has become one of the last retreats of the Semang (Negritoes) and Sakai (Blowpipe men), who are the two chief aboriginal races of the Peninsula. The scenery is magnificent, particularly on the Nenggiri River and on the upper reaches of the Galas River. There is plenty of big game, but the country is too close to allow hunting, and the only people who get any shooting are planters and engineers who happen to be on the spot; one sometimes hears of parties going out after seladang and elephant, but these expeditions are only occasionally successful. The chief species are tiger, seladang (bison), rusa (deer), tapir, porcupine and, in the south, elephant.

About eighty-five per cent. of the timber in the state is useless, and there is a shortage of chengai and merbau, which are the two most valuable hardwoods; also the absence of a properly trained Forestry Department has led to the devastation of the wild rubber and gum forests to such an extent that it has now become necessary

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to prohibit the exploitation of these jungle products. Soft woods are comparatively plentiful, but have hitherto been too inaccessible to be profitable ; it is hoped, however, that with the opening up of South Kelantan by the railway a prosperous timber industry may be developed.

The mineral resources of Kelantan have not yet been fully surveyed, but both tin ore and gold have been worked with success on a small scale by Asiatic methods (open cast mines), and although large-scale mining has hitherto been a failure, there is a reasonable possibility that, with improved facilities for transporting and prospecting, tin ore deposits in sufficient quantity to justify large-scale working may be found in the main granite range which divides the state from Perak, or in that which forms its boundary with Trengganu. Prospecting for tin is being done on a large scale, and a rich and extensive deposit of iron ore has been found at Temangan, which has easy access both to the railway and the Kelantan River, and is favourably situated for exploitation. It is understood that the concessions for this area have been let to a Japanese syndicate.

Hitherto the only means of communication in the state have been the rivers, and the bulk of the goods traffic has been carried on the Kelantan River, which is very shallow and difficult of navigation. Shallow draft launches and small passenger boats can get up as far as the Nenggiri River, but the difficulties of navigation increase so rapidly in the hilly country to the south of that point, that only native praus, some of which are now being fitted with outboard motors, and native poling craft can be used. Kelantan trades almost entirely with Singapore, and up to the present the traffic has been carried by small coasting steamers plying a regular service between Singapore and Bangkok, which call at Tumpat. Trade is much hampered by the lack of any natural harbours or sheltered anchorages, and the water is so shallow that steamers have to lie about two miles from the shore and load from native lighters ; during the north-east monsoon, which blows from November till March, communication between the steamers and the shore becomes very difficult, and frequently has to be suspended. The chief exports of Kelantan are rubber, copra, dried fish, cattle and betel nuts, and with the exception of the copra industry, which is confined to the coast, it seems likely that the bulk of the trade between the state and Singapore will eventually be carried by the East Coast Railway.

The East Coast Railway has a considerable tactical, as well as commercial, importance in facilitating communication and transport with the east coast of Malaya, and in relieving the main line of the F.M.S. Railways (through Kuala Lumpur and Penang) of through traffic in case of emergency.

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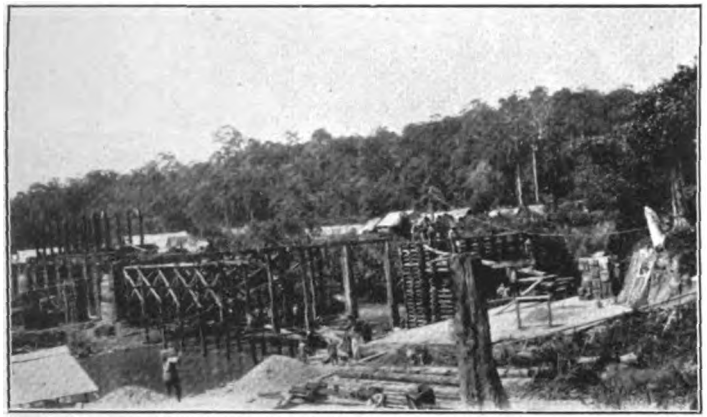
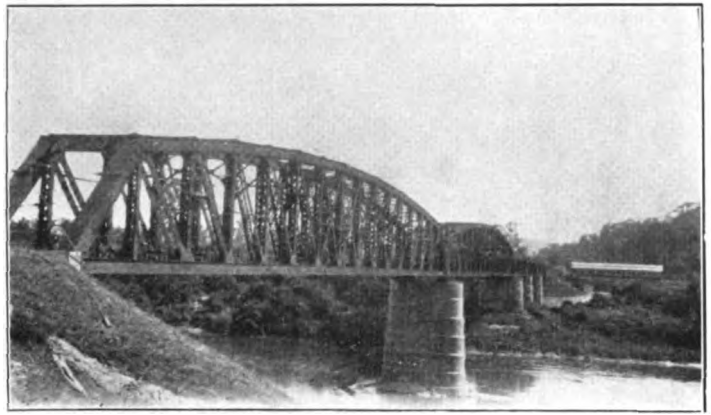
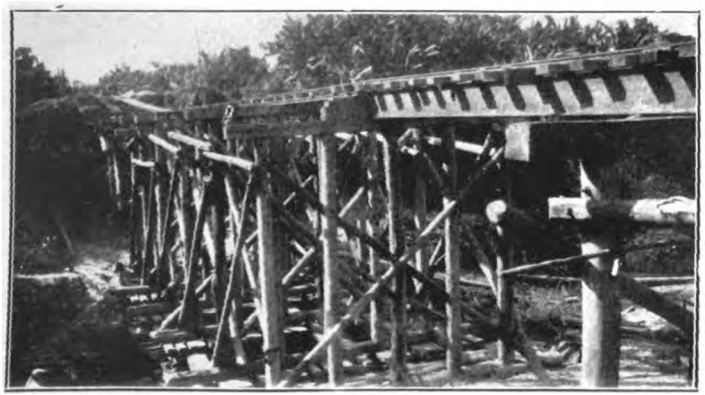
THE KELANTAN SECTION OF THE EAST COAST RAILWAY, F.M.S.R.



False work at Renoh Bridge site.



Manek Urai Bridge.



Temporary bridge of round jungle timber.

Temporary bridge of squared timber.

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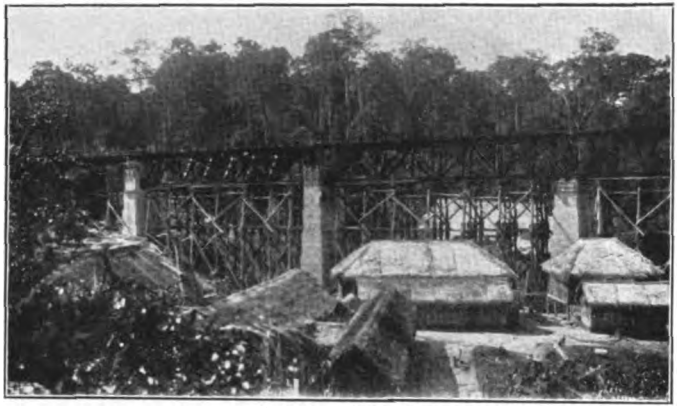
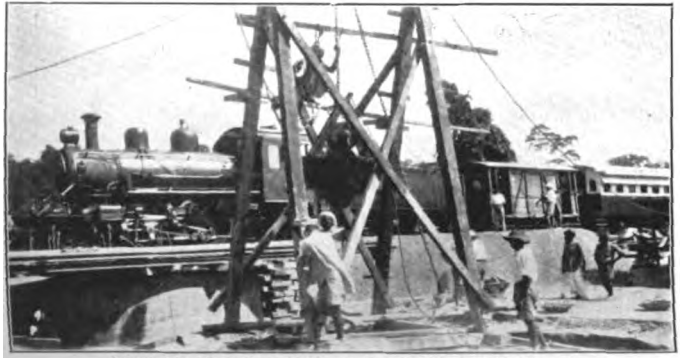
Kasuku Viaduct.



Kasuku Viaduct.



Well sinking for bridge foundations at Kasai.

Well sinking for bridge foundations at Kasai.

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THE RECONSTRUCTION OF THE TIDWORTH BRIDGE BY THE 17TH FIELD COMPANY, R.E., IN APRIL, 1930.

By LIEUTENANT W. B. SALLITT, R.E.

THE reconstruction of the "Old Black Bridge" at Tidworth had long been overdue. Built in 1910, as a temporary structure, it had been at best no more than a makeshift, knocked up at short notice with whatever money and materials were available at the time, and as it had aged it had not improved in appearance. Two of its spans were of steel and the remaining six were bridged with a clumsy arrangement of wooden stringers.

A centre pier in the middle of the main road had always been a danger to road traffic, and the bridge had also become dangerous for rail traffic. Many of its timbers were rotten, and although wedges had been inserted in nearly every joint in an effort to maintain correct rail level, when a train crossed the bridge timbers shifted, splinters flew and each span in turn sagged ominously. Unsightly trestles and crumbling abutments completed the picture, *vide* Photo 1, and it was a miracle that the structure had lasted so long.

The bridge was finally condemned, and in January, 1930, the 17th Field Company were ordered by C.R.E. 3rd Division (Lt.-Col. L. V. Bond) to work in conjunction* with D.C.R.E. Tidworth (Major H. E. Roome) and put up a new steel girder bridge, as part of its collective field works training.

The work entailed closing the W.D. Railway into Tidworth, also the main Salisbury–Marlborough Road, and consequently had to be done as quickly as possible. The Company were instructed to carry out the work as a continuous operation, and arrangements were therefore made to work continuously in eight-hour shifts. The last train was to pass over the old bridge at 2 p.m. on Thursday, April 24th, and it was estimated that the new bridge would be open to traffic at the same hour on Monday, April 28th.

THE OLD BRIDGE.

The old bridge, shown in detail in Fig. 1, was 131 ft. long, and had eight spans, whose lengths varied from 12 to 20 feet. It carried a single-line track, with rail level 16 ft. 3 in. above the road.

* The distribution of responsibility between D.C.R.E. and the Company worked out very well, and the actual instructions on this matter are given in detail in Appendix II.

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The two spans which bridged the main road consisted of composite girders, whose cross-section is shown in Fig. 2. The rails were spiked to 12 in. x 12 in. baulks, lying inside these girders, supported on three trestle towers.

The remaining spans, of which a cross-section is given in Fig. 3, had an upper and lower course of wooden stringers, separated by 9 in. x 9 in. traverse members. The upper course consisted of two 9 in. x 9 in. stringers supporting the sleepers, the lower of 12 in. x 12 in. stringers supported by corbels lying on the transoms, and two 24 in. x 12 in. stringers placed vertically beneath the rails and continuous over trestles I, V and VII.

Timbers were secured together with a profusion of dogs, bolts and iron straps, and the whole superstructure was a tangle of rotting wood and rusty metal.

All the trestles were of wood, except I and VII, which were of reinforced concrete. The bankseats, also of concrete, were castellated to prevent lateral movement of the stringers.

Between piers V and VI ran the River Bourne, and although barely 15 ft. wide, this stream was a source of trouble throughout the work.

Factors Influencing the New Design.

1. *Loads.*

The bridge had to take "Molly" and "Betty," the two engines which run over the W.D. Railway; axle load, 12 tons.

2. *Spans.*

(*a*) The Wiltshire County Council insisted on the removal of the pier in the middle of the road, and would not permit any reduction of the width of the road.

(*b*) On the grounds of economy, use had to be made of the four composite girders of the old bridge and four of the 18 in. x 7 in. x 33 ft. R.S.J.s obtainable from the Railway Training Centre, R.E., Longmoor.

(*c*) At least one of the existing abutments had to be used if possible.

The Design of the New Bridge.

The design of the new bridge consisted of four spans, giving a total length of 122 ft. (see Figs. 4 and 5). Wooden stringers were replaced by steel girders supported on wooden trestles, open sleepering took the place of the old close work, and guard rails and guard timber were also provided.

1. *Girders.*

The roadway of 41 ft. was to be bridged with four 24 in. x 7½ in. x 90 lb. R.S.J.s, the River Bourne with the four 33-ft. spans from

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Longmoor, and the two abutment spans were to be bridged with the old composite girders, which had to be crossed over during the reconstruction, so that the 22-ft. girders could be used on the east end and the 24-ft. on the west end of the bridge.

2. *Trestles.*

The design followed that shown on Pl. 29, *M.E.*, Vol. VIII, the legs and rakers being housed into the caps and sills. All serviceable timber in the old bridge had to be used again and, in consequence, trestle making could not begin until the entire bridge was demolished.

3. *Footings.*

The old footings were unsuitable for the following reasons :—

(*a*) As the old trestles had no groundsills, the old concrete footings had been shaped up to support the legs (*vide* Fig. 2) and thus could not be used for the proposed new sills.

(*b*) The old trestles in the middle and on either side of the road were not at right angles to the line of the bridge, but were parallel to the road. This had been desirable in the old bridge to reduce the effective width of the obstruction in the middle of the road, but in the new design, with its clear span over the road, slewed footings were unnecessary, and, furthermore, they would have thrown abutments out of square with the embankments and complicated the design of the former. It was, therefore, decided to erect the trestles square with the rails. The footings of trestles II and IV (Fig. 4) were to be altered to take the new trestles, and a new footing was necessary between the Bourne and the east abutment ; excavation for the latter had to be carried to a depth of six feet before a solid foundation was reached. Steel straps let into the concrete were to be used to secure the trestle sills.

4. *Abutments.*

Design took up for two concrete retaining walls, with earth filling behind.

As traffic had to pass over the bridge within 72 hours of the walls being built, it was considered essential to use concrete blocks. Temporary wing-walls of C.I. sheeting were to be erected to hold back the filling and to form the shuttering for permanent walls to be constructed later.

The new east abutment coincided in plan with the old abutment, but the castellations had to be removed and two courses of 1 ft. 6 in. cube blocks had to be laid to make up to rail level. The west

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abutment, a new construction 10 ft. long, 6 ft. high, and 1 ft. 6 in. thick at the top, was to be built with four courses of the same 1 ft. 6 in. blocks, to give an effective height from ground level to the underside of the girder of 3 ft. 6 in.

ORGANIZATION.

Whereas during the design the chief consideration had been economy, the ruling factor for execution was to be speed to complete the job within four days. The 70 available Sappers were divided into two alternating shifts, "A" Shift, 40 strong, and "B" Shift, 30 strong, and these had to work round the clock in the following reliefs:—6 a.m. to 2 p.m., 2 p.m. to 10 p.m., 10 p.m. to 6 a.m., etc. The disparity in strength was caused by the concentration of all the carpenters and bricklayers in "A" Shift in order to expedite trestlemaking and abutment construction on the second day.

To speed up things to a maximum, it was decided to use all available mechanical resources. All derricks, ordinary holdfasts, winches, etc., were to be dispensed with and the girder launching, trestle erection, etc., was to be carried out with our own derrick lorries (Morris and Guy), supplemented by a 2-ton portable crane on loan from Ordnance. A list and short description of the power tools available in the Company is given in Appendix I.

Preliminary work comprised:—

Under D.C.R.E. Arrangements.

The new concrete footings were prepared a month before work started and the necessary number of concrete blocks were cast for the abutment walls.

To admit of night work being carried out continuously, five 20-ft. poles, carrying powerful flood lights, were erected on the site.

Two trucks filled with earth were shunted into sidings on either side of the bridge for use in the abutments.

Under Company Arrangements.

Each trestle in the new design was numbered, each member of it was given a letter, and all sound timber of the old bridge was earmarked, so that on dismantling it could be quickly dumped where required for trestle making.

The 45-ft. and 33-ft. girders were off-loaded from railway trucks on the embankments on each side of the bridge.

A temporary bridge of pontoon superstructure was laid over the Bourne between piers IV and VI (Fig. 4), and subsequently another bay was laid alongside it to form a wide platform on which the derrick lorry could manœuvre.

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The Work.

It had been estimated that the job could be completed in four days, as follows :—

1st day—dismantling.
2nd day—construction.
3rd day—erection and launching.
4th day—sleepering, platelaying and clearing up.

Parties commenced work on Wednesday, 23rd April, when the preliminaries of clearing the site, laying a bay of pontoon bridge, etc., were carried out.

" A " Shift, starting work at 6 a.m. on Thursday, drew tools and stores, erected a store tent and loosened all accessible nuts in the bridge (Photo 1.)

The last train crossed the bridge at 2 p.m. ; " B " Shift came on at the same hour, accompanied by heavy rain, and it was soon very difficult to walk on *terra firma*, whilst movement on the timbers and girders of the bridge was most precarious.

The first problem met with was the freeing of the 12 in. x 12 in. baulks out of the troughs in the composite girders. It was hoped to be able to lift these baulks out of the seatings and use them as ways over which to slide the girders out on to the embankments, but this proved impossible for, even when all wedges had been removed, the baulks were found to be held fast by the bitumen which had been poured in between them and the girder webs. The derrick lorry was called to the rescue and with it all four composite girders, each weighing some four tons, were lowered straight down on to the road. The extraction of the 12 in. x 12 in. baulks was not easy and various methods were tried in vain.

The method which eventually proved successful was to drive a bolt into the end of the baulk, by means of which one end of the girder could be picked up by the derrick lorry ; the girder was then hammered downwards with sledges until steel wedges could be driven in between the flange and the baulk ; once a start had been made in this manner, extraction became a matter of minutes.

Meanwhile, the demolition of the wooden spans was causing much trouble. Most of the nuts had to be mutilated as the bolt heads were either inaccessible or countersunk and could not be prevented from turning round in the rotten wood. To add to the troubles, many of the timbers, which weighed nearly a ton each, could not be lifted by hand off the bolts ; nor could the bolts themselves be driven out. Again, various methods had to be tried, and the most successful proved to be to harness the baulk to a lorry by means of a tow rope. In nearly every case the bolt either sheared or buckled when the lorry was driven off down the road.

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By 6 a.m. on Friday, the four composite girders were in the road, the end spans had been cleared ready for abutment construction, and although most of the trestles were still standing, it was evident that these could be easily pulled down by the derrick lorry.

Trestle construction was slightly delayed, owing to the trouble experienced with the composite girders, and could not be started till 10 a.m. on Friday; in consequence, it was decided that the 6 a.m. shift of carpenters would have to work right through until 10 p.m. This meant a 16-hour shift on top of a soaking, but the men worked splendidly, and by 10 p.m. on Friday, four trestles were finished, two abutment walls had been built and the general picture at site is shown by Photo 2.

The next shift had the trickiest part of the trestle erection to deal with, and as it had poured with rain all night, working conditions and visibility made things none too easy for them. Of the four trestles ready for erection, two formed the pier on the east side of the Bourne. The derrick lorry could lift the trestles just high enough to drop the sill in between the iron straps of the footings, but it could not carry them to the site, owing to their weight of 2 tons each. The crane, on the other hand, could carry the trestles about but had not sufficient lift to place them in position. In consequence, both crane and lorry had to be used in conjunction and the manœuvring involved was a lengthy and tricky operation. In the attempt to reach pier VI, the crane became bogged in a short length of ground between the road and the temporary pontoon bridge, and it was necessary to lower the trestle on to the ground, extricate the crane without its load and man-handle the trestle forward, until the derrick lorry could manœuvre near enough to lift it into position. All this proved a long process, but eventually two trestles were erected and braced together by 4.30 a.m. on Saturday, and another party had finished filling behind the new abutments, using earth brought to site in railway trucks.

In the meantime, it became necessary to extemporize a method of raising the composite girders out of the roadway on to embankment level. The method adopted here was the use of locos. as main tackle, primitive perhaps, but requiring careful manipulation. Having raised the girders in due course, it was then decided to launch first of all the two which spanned the east bay. It had been hoped to launch these over the standard equipment box girder rollers, but the rivets projecting from the bottom flanges made the first girder bounce so alarmingly that the method was voted too dangerous, and the second girder was pulled out by the derrick lorry, with the Morris on the embankment acting as preventer.

The remaining trestles were up by 4 p.m. on Saturday; unfortunately, however, one of them was slightly out of plumb, but as this trestle had been finished by night and in pouring rain, with only

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the headlamps of a lorry for the men to see by, this defect was perhaps excusable. To remedy it, the bracing had to be removed and a sling fastened round the cap, and attached to the crane cable; the trestle righted itself on winding in, but sprang back when tension was released. Quarter-inch steel wedges were, therefore, hammered in between the raker and the sill, the trestle was properly trued up, and all was at last ready for the remaining girders.

The span which now had to be bridged was the centre one over the main road. It was known that the launching of the 45-ft. girders quickly and without derrick, holdfasts, etc., would have to be very carefully arranged for, and the following was the method it was decided to try out. To save time, the four girders were bolted together in their pairs prior to being launched. A Morris was driven along to a level crossing, a quarter-mile from the west abutment, and thence backed along the railway line to the embankment for use as preventer tackle. The medium derrick lorry was positioned for use as main tackle as in Photo 3, but to the east of trestle IV of Fig. 4. The pairs of girders were then launched out over box girder rollers placed on the cap of the new trestle 2 (Fig. 4), and also on the cap of the old centre trestle, which had been left standing (*vide* Photo 2) for this particular purpose. When the nose of the girder had been hauled close up to trestle IV (Fig. 4), the nose was allowed to dip to free the roller under the tail at trestle 2; the tail was then positioned on trestle 2, the nose raised to free the roller on the old centre trestle, and the nose then finally lowered on to trestle IV.

Both of the centre span pairs of girders were launched in the same way, they were out by 4 a.m. on Sunday morning, and when it became necessary to remove the old centre pier, it was found that it required very little persuasion.

The derrick lorry was then run round underneath the 45-ft. girders and its derrick erected between them to launch the 33-ft. girders from the eastern embankment. The other Morris acted as preventer, and the girders were slid out with very little trouble, inside the channels of the composite girders.

The two remaining composite girders were slid out on rails, using the Guy and Morris again, and all the girders were over by 11 a.m. on Sunday.

The remainder of the day was spent in lining up the girders, taking levels and making the necessary small adjustments in height. All levels were corrected, so as to give a constant gradient, accurate to $\frac{1}{8}$ in., over the bridge. These necessary adjustments proved aggravating and tedious for, after three successive nights out, the brain was not at its best for accurate levelling work and computation, whilst packing involved the raising of each girder in turn.

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Sleepering commenced at 11 p.m. on Sunday, and the first truck (empty) crossed the bridge at 8 a.m. on Monday, by which time the bay of pontoon superstructure over the Bourne had been dismantled and a great deal of clearing had also been done.

Monday morning was spent in fastening down the guard timber, a job in which the pneumatic wood auger proved the greatest value, and making up under the new sleepers on either embankment. The centre pier was also demolished, the concrete base pillars being removed bodily with the lorry and tow rope. The stumps and base were finally demolished with the compressor and a road maintenance party had the road open to traffic by 2 p.m.

At the same moment, "Molly," who had been getting up steam all the morning, appeared with two trucks, and as the shifts were just changing over, the whole Company saw her pass over the bridge, 96 hours to the minute after the last train had crossed the old bridge (Photo 4).

CONCLUSIONS.

1. From an engineering standpoint, the outstanding feature of the work was the value of the medium derrick lorry and the compressor, whose engines ran almost continuously throughout the job.

It may be of interest to tabulate the tasks performed by the derrick lorry, and consider how much longer these would have taken, using any form of standing derrick with its accompaniment of tackles and holdfasts.

(*a*) Off-loading eight 2-ton girders from railway trucks.
(*b*) Lowering four 3-ton composite girders from a height of 16 ft. into the road.
(*c*) Extracting the 12 in. x 12 in. baulks from inside the composite girders.
(*d*) Demolishing the old timber bridge; the combined lifting and towing properties were invaluable.
(*e*) Turning over trestles during construction (5 minutes).
(*f*) Towing crane into position.
(*g*) Erecting trestles.
(*h*) Launching girders weighing up to 3 tons over gaps up to 45 ft.
(*i*) Positioning girders on trestle.
(*j*) Lifting up guard timbers from the road and depositing where required on the bridge.
(*k*) Picking up and placing on trailers for removal about 30 tons of timber in 2½ hours.

The compressor was used a great deal for augering and concrete-breaking.

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THE RECONSTRUCTION OF THE TIDWORTH BRIDGE BY THE 17th (FIELD) COMPANY, R.E., IN APRIL, 1930.

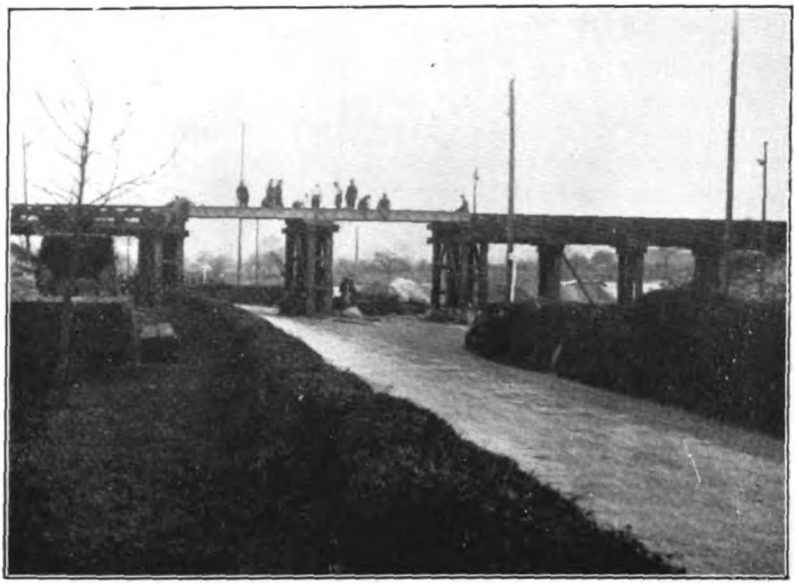

Photo 1.—The old bridge (2 p.m., first day).

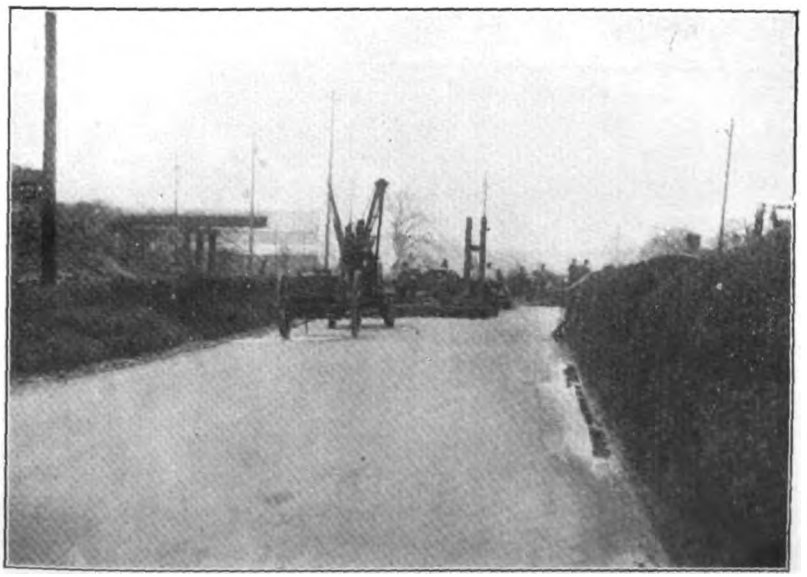

Photo 2.—After 16 hours.

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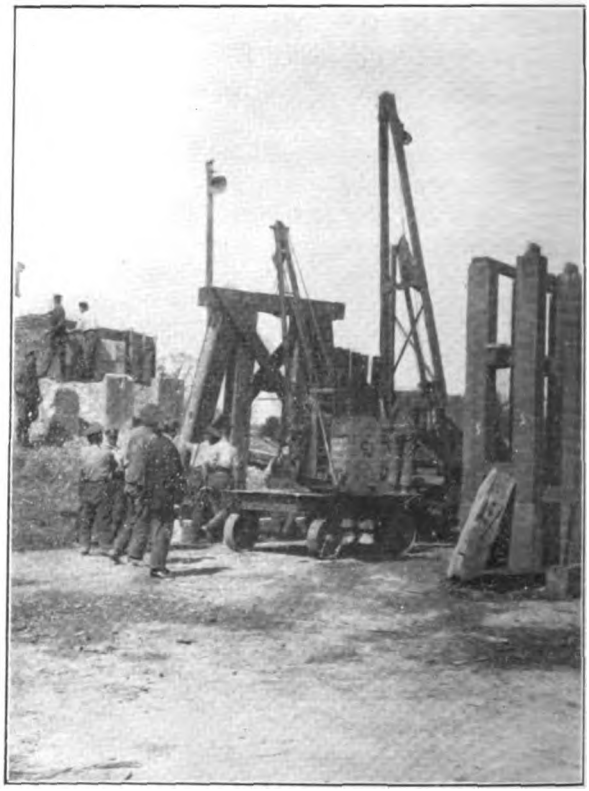

Photo 3.—After 40 hours.

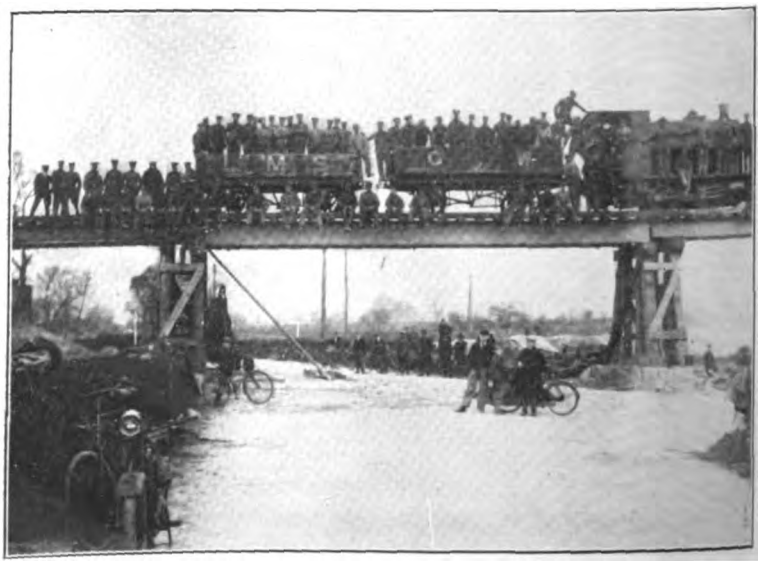

Photo 4.—After 96 hours.

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2. The work served as an illustration of the twofold value of mechanization in a job of this type, when conditions approximate closely with those obtaining on active service. Not only was the work simplified and accelerated by the use of power tools, but the efficiency of the men themselves was enhanced; although the bridge was five miles from Barracks, the work could be carried out without camping at the site, and thus the men could be provided with hot meals in Barracks at the beginning and at the end of each shift.

3. A further conclusion was that the alternative eight-hour shifts could only be worked on jobs of comparatively short duration. A man needs more than eight hours to get rested, especially if the eight hours include two meals and two five-mile journeys in a lorry. Although even on the last day there was no diminution of efficiency or enthusiasm for the work, the pace could hardly have kept up for more than another day or so.

4. An oxy-acetylene plant is essential for work of this nature, and the one borrowed from Ordnance had plenty to do.

5. It would not have been possible to attempt to carry out a job of this size and urgency had the Company not been a mechanized Field Company.

APPENDIX I.

Power Tools Employed on the Work.

(1) A Guy 6-wheeler derrick lorry, having a derrick mounted on the rear of the chassis. Height of derrick, 21 ft., and capable of being erected in half a minute.

The winding gear gives a 4-ton horizontal pull and will lift 1 ton without sprags, and 4 tons with them.

(2) Two 6-wheeler Morris tool lorries with a winding gear giving a 3-ton horizontal pull. The cable can also be carried over a 10-ft. derrick mounted in the rear of the chassis, whereby weights of 15 cwt. or 3 tons can be lifted with and without sprags respectively.

(3) An Erco band saw, driven by a small petrol engine of the motor-cycle type; this can be operated by three men and is held in position by means of three handlebars. It will cut through a 12 in. x 12 in. baulk in less than a minute.

(4) The compressor, capable of working two pneumatic tools simultaneously. The following were employed on the bridge:—

(*a*) Concrete drill.

(*b*) Concrete breaker.

(*c*) Wood auger. Thanks to the R.E. Board, this machine had been supplied from the Consolidated Pneumatic Tool Company, and proved invaluable. It will bore a ¾-in. hole through 12 in. of new oak in 45 seconds.

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(5) In addition to the Company tools, a 2-ton crane was loaned by Ordnance; this gave only a 14-ft. lift, and although very unwieldy to move about, it provided valuable assistance in erecting trestles.

(6) An oxy-acetylene plant, also loaned from Ordnance, was used to cut the straps securing the legs of the old trestles, and for welding up several of the new straps which were damaged by the fall of timber during the dismantling of the old bridge.

APPENDIX II.

EXTRACT FROM C.R.E. 3RD DIVISION'S INSTRUCTIONS FOR COLLECTIVE TRAINING PERIOD, 1930.

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6. *Field Works Schemes.*

The following special or combined schemes will be carried out :—

(1) *Scheme A (Heavy Bridging)—17th Field Company.*

Repair of Railway Bridge over the main road opposite Lucknow Barracks, Tidworth, for D.C.R.E., Tidworth.

The O.C. 17th Field Company will be responsible for :—

(1) Checking D.C.R.E.'s design, calculations and list of materials for incorporation in the work.

(2) Assisting D.C.R.E. with an officer and draughtsman for making the detailed working drawings (this officer will also assist the D.C.R.E. for getting out list of materials).

(3) Working out scheme of erection and providing (or indenting on D.C.R.E. for) the stores required for erection, including the lighting set for night work.

(4) Providing loading and unloading parties as necessary.

(5) Receiving, stacking and accounting for all stores and materials at site.

(6) Arranging with D.C.R.E. the date of erection (D.C.R.E. will arrange with local authorities).

(7) Arranging with Garrison Adjutant for allotment of site for camp at the material dump, sanitary services, etc.

(8) The erection of the bridge (and safeguarding the public during erection).

(9) Clearing the site.

All expenses will be debitable to the D.C.R.E.'s allotment for work, except expenses of camp and move, which will be charged to the T.G. of R.E. 3rd Division.

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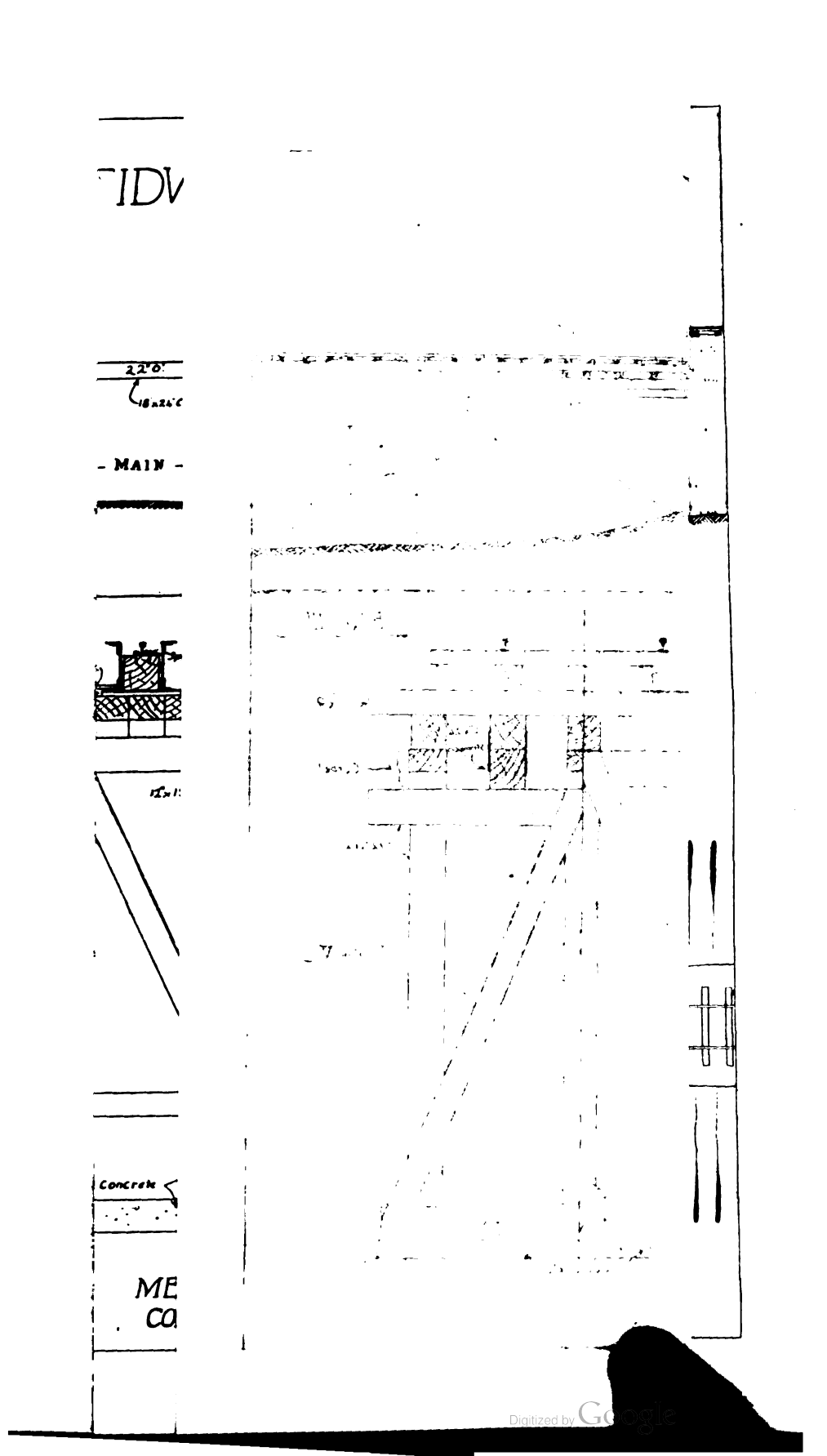

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~ TIDWORTH

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FIG IV

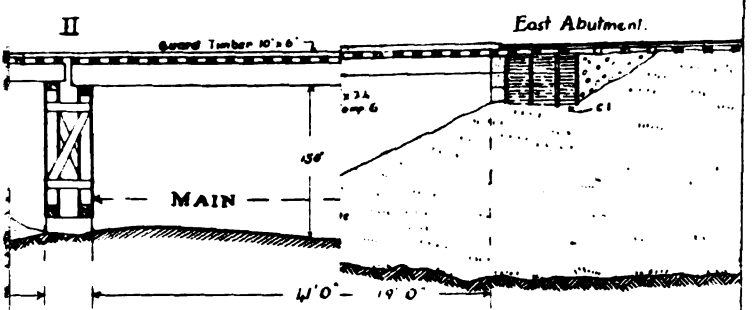
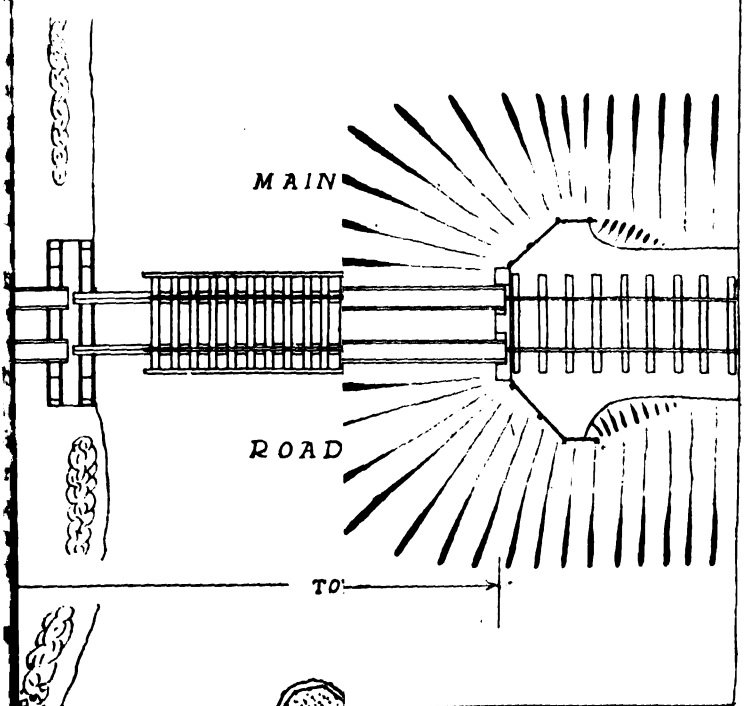


FIG V



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THE ABOR MILITARY AND POLITICAL MISSION, 1912–13.

(*Continued.*)

Compiled from the Diary of the late Captain P. G. Huddleston, R.E.

3. The Siyom (*Continued*).

Feb. 27. Puitgong-Siyom junction. Seemed hopeful in early morning, and at 11, the beastly barometer having risen, I determined to get across the Siyom. Two (6 bamboo) rafts had been made the day before and these were carried down half a mile to the mouth of the Kebung and joined together, and at 1.30 the first party went over. Then a thunderstorm came on and it rained cats and dogs till dark, by which time only half the party were across, as the Siyom was coming down in flood, and at each crossing the raft was swept down about 300 yards. So I had to take the other half back to camp.

Feb. 28. Back with remaining half of party by 7.30, and got across, paddling the raft myself, which I found hurried things much more, though most tiring. Clouds still too low for really useful work. Camped at Rengku village. Minyongs frightened at first, but quickly got reassured and friendly. To bed. Raining again.

March 1. Started with rations for two days for Yillo Hill, 6,430. Cleared ridge at top of hill. Very cold, but plenty of good firewood. Mist rose and gave fair view. Worked till dark.

March 2. Rushed to hill, 100 yards along ridge, half-dressed, at dawn and got most wonderful view of the Po, Yorking and Parri snows. Lovely! Hamid Gul worked solid to 11 a.m. He surpassed himself and knocked out a splendid bit of work. I took heights with 3-in. theodolite, and questioned the Abors, both breakfasting while working. Splendid day. Reached Siyom, 5,400 ft. below, by 2.30; across 4.30. Took reading for Siyom level just before dark. *The Siyom comes from the north-west. Hurrah!**

March 3. Kaying camp. Boris will not come in and parley, and there are no signs of them yet. These Kaying and Tumbuin Minyongs are between the devil and the deep sea. They want, and are frightened not to help us, but if they do, they are frightened that the Boris will punish them by stopping their salt, etc., when we go away. I think things will probably be talked over when we get two marches on, but it certainly now looks like war, in which case I will

* This was one of the points the party were to clear up.—Ed.

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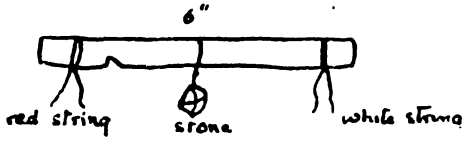
gladly lay down my theodolite for my pistol. They say the Boris' plan is to get us unawares in camp and rush us all at once, the usual tactics on this frontier with small parties. What we hope they will *not* do is to booby trap the precipices and cut down the bridges, etc., as it means we have to go so slowly. Another fine day, so the luck is with us. The work from the Yillo was a gift, and Hamid Gul will be working on the rays from it till the end of this Siyom sideshow.

March 5. Work very satisfactory. Rain starting again. Situation still interesting. Messages as below flying about. It would be interesting to collect more of them. Yesterday's from the Boris was thus :—



The notch means having come more than half-way into the country ; if we return, that is to the white string, it will be peace ; if we go on, *i.e.*, to the red string, it will be war ; the stone tied on means that their hearts are as hard as stone. In 1894, when the expedition started, the Danroth Padan Abors sent a bundle of hair, a handful of sand, a piece of charcoal wrapped in red cloth and a chile (red capsicum). The meaning being that their men were more numerous than the hairs of a man's head or the sand of the river shores ; that hearts were evil and bent on fight (black as charcoal, wrapped in red for blood), and that they were as keen or hot as chile for the fight. A stone in a basket also came in yesterday for one of the interpreters, which meant his son was ill (the hearts at home heavy).

March 6. Off 8 a.m. to the Sikon-Siyom junction just below Tumbuin, only 4 miles odd, as the coolies have to go back each day and bring up more rations, we neither wishing nor insisting on too many coolies. Rained hard all the time and it was beastly while the camp was being cleared and built. Porter and Hore determined to go cautiously and take no risks. The coolies and khalasies have made themselves spears from bamboos and hardened them in the fire. Still raining, but most comfy in our little hut.

March 8. Rain all night. Hore in at 10.30. Yangking *gâms* came in to say Mega Bori *gâms* would not come in. That the Boris were making booby traps above the path across the face of the cliff opposite and were cutting the bridge and that all the Bori of the near villages (400–500) were encamped in Mega, across the bridge. They then said to our *kotoki* Yango that he should come with them and they would show where the traps were. Very pluckily he said " Yes," and Hore took the risk of letting him go. Sure enough, as Hore guessed, all these stories had been bluff to try and frighten us, and

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in half an hour Yango was back with 2 Bori *gâms*, who came in very frightened to make a personal try to stop us. Yango had found no booby traps, but only 20 Boris making a small stockade on the part opposite, as a sign to us not to proceed. The *gâms* went away, saying they did not want to fight but that, if we insisted in coming into their country, they would. They will probably make the best of a bad job and let us in quietly. This, for survey work, is just what we want, though I must say I feel disappointed at not having a bit of a scrap. Rain most of the day.

March 11. Rained all night. Porter in at 7 a.m. About 2 hours after dark, in spite of the candles we had sent them, 3 fellows had fallen down the *khud*: only 10 ft., but Porter decided it was too dangerous to go on. Lighting fires on the narrow path, he spent quite a passable night and wasn't too hungry next morning.

March 12. Nyoro Sibo camp. A two-shift *bandobast*, but delayed by having to build a temporary bridge over the Sire. Whole move about 2 miles. Rain all day. Beastly camp.

March 13. Opposite Bogu. Two-shift *bandobast*, but only 1½ miles. Not suitable camping ground ahead. Rain all day. Camp more beastly. We are moving so slowly, I fear I shall not be ready at Bogu when the rain stops, but Hore and Porter wish to keep concentrated till relations are established with the Boris, hence we all keep within a mile of one another. As they truly say, loaded coolies with a few sepoys are always a source of danger.

March 14. Started 8.30 a.m. As Hore and I rounded a corner, we saw the Bogu bridge (cane suspension) with one end lying in the water, and some 20 Boris on the opposite bridgehead who had evidently been waiting our approach to cut it down. On reaching the bridge, we also cut it down from our side, which will give them more trouble to repair. We then went on and the Boris opposite started shouting. The two *kotokis* went down the river and tried to get them into conversation: two came down to give signs of fighting and the rest bolted on ahead, evidently to warn others. We then reconnoitred on a little, going very cautiously at any nasty places in case of stone shoots, and decided to camp at the broken bridgehead; returned, followed on the opposite side by more Boris, one of whom had the impertinence to fire his arrow at us. While camp was being made, Hamid Gul and I cut a path up the hillside above and got a view of Bogu, and I made a small eye-sketch of the paths up to it. Also saw Payum and the Sike River at last. Cut some bamboos for rafting on way back. In camp at Bogu bridge at 5 p.m. Really quite an interesting day and it looks as if the Boris meant business at last. We heard from the Dihang that 200 Membos or Tibetans were with the Jambo Boris. We must now effect a junction with the Shimang parties and our convoy.

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March 15. At night we were disturbed by a big tree, which crashed down through the jungle above us, and for a moment we thought the Boris had some game on. Coolies went off early to get some bamboos. Boris shouted across to us and we parleyed fruitlessly across the Siyom for about an hour. Porter and I went off to reconnoitre Siyom-Sike junction, which we reached, going very cautiously in case of traps, in about an hour. Good pool for fishing from other bank, but not long enough to run a big fish in. Saw some 32 Boris returning up-stream. Porter returned to camp. I went up spur above the junction, cutting a path for 2 hours. Wearing and dirty work. Cleared a little space and saw another village, Gameng, up the Sike; also Payin bridge over the Sike. The Yiyu bridge over the Sike is 200 yards over the junction. Have seen no other bridge over Siyom. Back 4.45. Only one raft ready and Boris have been shooting with arrows (wooden ones only) at coolies getting water from the river. No one hit, and they are probably only getting the range for our crossing.

March 16. Great discussion till 8 a.m. Porter for further delay, and I for not waiting after the 17th. Hore eventually decided on 18th. Self went down river for more bamboos. Returned to find Hore and Porter going over to have a parley with the Boris, who had come down unarmed and wanted to talk over matters. Did so and 3 of them returned our visits and were given presents. This sudden change of front is curious and probably has some outside reason. Bother! Bang goes a chance of a most exciting crossing under arrow fire. Two more rafts made (by 15 men in 2½ hours, with bamboos all ready) large enough to carry two paddlers and 3 or 4 men with rifles, etc. Great discussion in evening with Porter about the advantages of patience and giving these tribes around Assam time to cool down.

March 17. Porter and 18 rifles were paddled across at 7 a.m. No Boris in sight. They were up on the fields above the gorge by 8.15, which made the crossing absolutely safe. Whole party over in 3½ hours, using first 3 rafts, then 4. Towards the end, only 3 men or 6 loads allowed for each raft, as these green bamboos leak a bit and get less buoyant after some hours and there is always a risk of them buckling in the centre suddenly, as happened last year. Camp on fields near streamlet some 600 ft. above the river and 1,600 below Bogu village. Several Boris, men, women and children, came down to the camp and protested absolute friendliness, swearing it was the next village that had shot arrows at us and been so defiant. The villages also seem too small to muster sufficient numbers against us. Magnificent view of the Parri snows from the front door of our *basha*. The *damdin* flies are pretty bad and most of us have sore hands or knees.

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March 18. Went up hill above with Hamid Gul. Hore having great discussions with various Bori *gâms*. Bogu very friendly. Nice to get some chickens again. Long time since we had any fresh meat.

March 19. Rain all day. News that Meade and Oakes will be in to-morrow.

March 20. Oakes and Meade in p.m. and rearguard slept the night out in the rain on the hill above. They have had very hard marches to get here in 6 days from Dosing and have to rest to-morrow to recoup. Things seem to have been going badly and I am beginning to doubt if we shall reach the falls this year. Oakes, when visiting Milang (or Orlong) on the Yamne River, was told of a Tibetan who came through 30 years before, and it seems there is no doubt it was Kinthup, who came down from Tibet, but was stopped by the Padan Abors. This practically proves that the Tsan-po is the Dihang, and shows how accurate Kinthup's report was.

March 21. Settled our programme with Hore and Porter. Willy-nilly, we must be back to the main line by about April 27, asking for more convoys or *dâks*. So we start to-morrow and hope for fair weather and luck. Yiyu *gâms* in, so it looks as if we may get through splendidly. They are in an awful funk, and think we want their country.

March 22. Oakes and Meade went off with returning convoy, taking back theodolite, camp bed, spare clothing, etc., as every coolie will be of value during these last 6 weeks till we get back to the main line. With the convoy came out a Tibetan interpreter, quite well educated, and knows a lot about these tribes. He says the Mimats are an outlying tribe of Tibetans on the N. side of the main range. They are not cannibals. They are very short-necked, and it is said of them, " They make much glad if they fall down, as can then see heavens." But I fear they will be on the other side of the frontier and we shall not have time to see them. To-day we shifted with 6 weeks' food in 4 shifts to a camp on the Sike-Siyom junction, and Hamid Gul and I worked from a field hill just above the village, with a view up both the Sike and Siyom. Though the *gâms* had got over their fright it was some time before the villagers came out of the village to look at us. But, by the afternoon, they were reassured we were not really going to be brutes, at any rate for the moment, and we were surrounded by the whole village, including women and children, making signs and examining our clothes and accoutrements and thoroughly enjoying the treat. This tribe has never been allowed by the lower tribes to trade down to the plains and had only heard of us as the Maharani's people. The immemorial custom of these parts is that each tribe remains in its own area and does not allow surrounding tribes through that area. Though trade

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is busily carried on between them, there are no through-traders. Hence you will see that some tribes who have more to sell are beginning to see the advantage of our opening up the country, as then they can get through themselves to the plains.

March 25. Yiyu camp. Attitude of Boris still a bit doubtful. Preparations for start to-morrow. Porter remains here in stockade with 12 rifles and Hore and I with 36 rifles and 18 days' rations make a dash up the Siyom.

March 26. Off at last, after finishing Porter's little fort for him. Passed under cliff, where there were marks of removed booby trap, so these Bori villages are hedging. Passed through Dupu and camped just beyond. Plenty of women and children. Seemed friendly and not frightened. Weather fine, but dull haze, and cannot see clearly more than 4–6 miles. The guide ("Mutton face") tells of 30-40 villages in front, some big, so we may be forced to return in the end. They say that the path, which is obviously precipitous, has been blocked and the galleries broken down. A silly ass of a sepoy has cut his knee with a *kukri*.

March 27. Hamid Gul and I went ahead and we all got into Ro about 11 a.m., the sepoy hobbling with difficulty. Great nuisance, and has decided Hore to halt to-morrow, especially as it is safer to reconnoitre the road ahead first. From here start the precipices of this extraordinary gorge the Siyom has cut west to east straight across the Parri-Yorking snow spurs of the main India-Tibet range. The Ro *gâm* says he will show the path up to where it has been broken by the next village, Pa-um, but no man can get through now. There is a lot of lying done in this country. Village brewed *apong* for us, and Hore and I chatted with them after the camp had been built. My watch, which I tell them is my sun, always fills them with wonder, as they think the ticking is that of a small animal alive, working hard inside to make the second hand go round like the sun. We now have the story that one or two rich Tibetans, possibly Chinese, came over the Siyom pass a few months ago with 50 coolies, and that the Boris murdered him (or them), sacked the stuff and sent the coolies back. The passes are not yet open, but remain open it seems from about May 15 to December 1.

March 28. Not a bad day. Camp halted for the sick sepoy. Hore and I went ahead to reconnoitre. After 1½ hours' walking (passing one stone shoot which had been let down, on the way), reached the path where it crosses a ravine and ascends straight some 600 ft. Then it goes along a bare cliff, the most terrifying place I have yet seen, with rock or earth slides overhanging it in places. The path creeps about half a mile across the cliff, with 3,000 ft. sheer slide or drop, with nothing between you and the Siyom. The path up to the ravine had been on the side of a very steep, rocky, jungly-clad slope, but comparatively easy and very well-marked, showing

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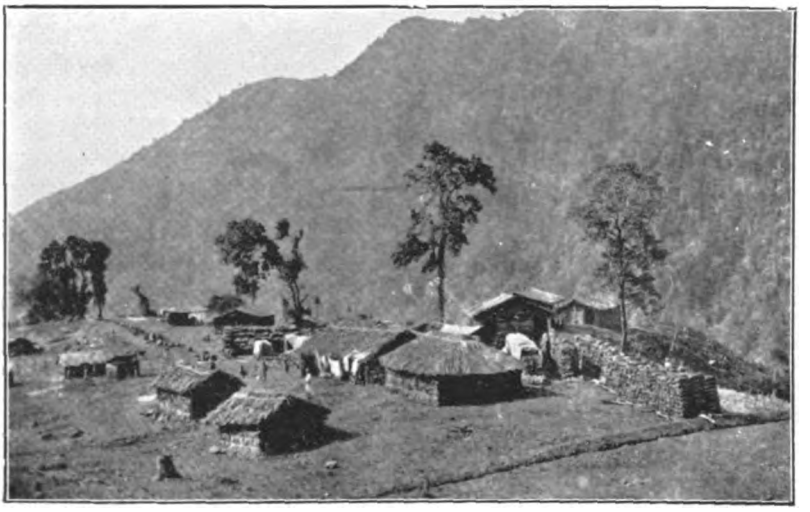
THE ABOR MILITARY AND POLITICAL MISSION, 1912-13.



Rotung Village.

Temporary Bridging.

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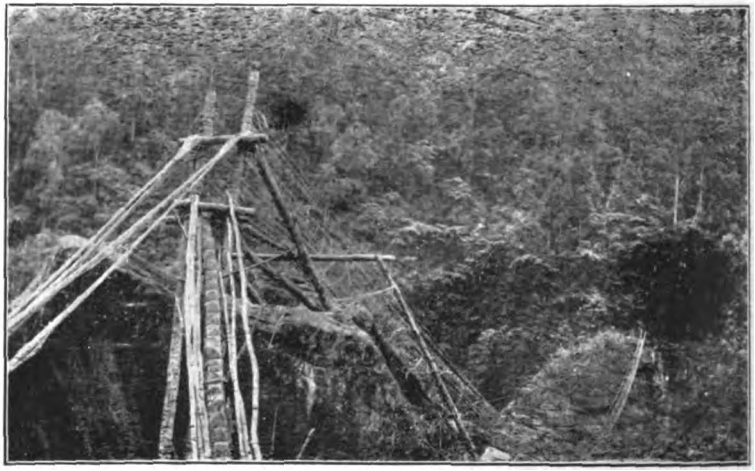

Memka Bridge.
(Some are 300—400 feet long.)

Looking up the Siyom Gorge, from above Yiyo village.

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it the main high road for the Boris in the upper Siyom. At the ravine we heard the sound of tree-cutting, and then saw the path ahead was blocked, a ladder taken away, and a pile of stones on top. Hore, who, though he has worked hard for peace, is dying for a scrap, managed with some 4 rifles to scramble round the first obstacle and then ascending the ridge to the left of the path, got some 700 ft. above the ravine. This, we think, made the Boris bolt, and leave the stone shoots they were going to make. Here I joined him, having previously left an ambush in rear, and the Ro *gâm* (who had been our guide) in their charge with strict orders not to let him bolt, and to gag him if he made any noise. We then got back to the path and worked up through the debris of fallen trees to where it reached the ridge and started crossing this awful chasm. It was obviously madness to go across at once, as the chances were that there were stone shoots above which would have swept us all down 2,000 ft. below. I suggested that I had better remain the night here, as it made sure of the path up to this point, and I could send 3 men to see if they could get up the hill above and so round this precipice. Consequently, here we are, 8 rifles and myself, 3,500 ft. up on the edge of this beastly precipice, with 2 water-bottles and some bread and 2 sticks of chocolate to sleep the night out, all for the sake of mapping a little bit more of this corner. Bah! It is coming on to rain, but luckily we have been able to rig up something of a shelter.

March 29. The shelter proved of very little value and it was a wretched night. The 3 men sent out did not return, being benighted on the hill above. As soon as it was light, having placed the ambush again and taking one sepoy, we crept about half-way over the cliff. We did not go right over because it was probable that the Boris would be watching that end. The path is generally cut in about 2 ft. but in 2 places it was merely small ledges of an inch or two on the rock for foot and hand and some of these places were across a diminutive ravine. We crawled across very gingerly while the Siyom roared up to us through the mist from below our feet. After getting back, the 3 sepoys soon turned up, having got up (in some places pulling themselves up with their rifles) to above the cliff, had found no stone shoots, but had seen a similar cliff round the next corner. The plot now thickens. Still leaving my ambush (now 5 men) at one end of the precipice path, I took the 3 remaining sepoys to the ravine stream, clearing the path of the debris on the way. We were washing in the stream below, when our breakfast rolled up and a chit from Hore to say he had rounded up Ro village at 4.30 a.m. to find it empty. They had evidently had guilty consciences and had bolted across the river at midnight. Hore had rounded up the village to get men as securities to go across the cliff first, and said he was coming on as soon as camp was struck. Meanwhile, the relieving ambush piquet went up while I had breakfast, and after

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some delay returned with the full armour of two Boris. What had happened was this. Soon after I had gone, the sentry warned the ambush of two Boris approaching across the cliff and, getting ready, they apparently surrounded them, but in their efforts to get them alive, let them both break through. The two Boris, brandishing their swords like Dervishes, jumped into the jungle and got away, goodness knows how, but leaving their weapons, bows, arrows, etc., behind. This was sickening. The sepoys ought not to have bungled it, though it is no easy matter to catch two slippery savages alive. We wanted them not only as guides, but also as ransom to start parleying with the next village, Pa-um, across the cliff. But almost immediately afterwards came another chit from Hore to say that hostilities had commenced at the village and he wished me to come back. So I quickly returned to the piquet and retired in a circle, so that the Boris, if watching, would think we were just sending a flank up to get them in rear, and then quietly retired down into the ravine, as there was slight risk that they might spot we were retreating and dash across to hurl rocks down after us. The two Boris who had escaped, not expecting that we should sleep the night out, and not expecting us very early, had come across to pile rocks ready for our coming. We could hear many others cutting down trees and shouting to one another on the other side, evidently making all haste to give us a warm reception. Got back to Hore about 1 p.m. Just as they were moving out of their camp, two Boris had shot at them, with arrows, and some coolies had a narrow escape. One also threatened the *kotoki*, who tried to prevent their shooting. So Hore opened fire, and though one fellow very nearly got a bullet through his head, to the sepoys' shame neither was hit. No doubt these were young bloods, but this was really a bit too thick and war was then and there declared. When the Boris had bolted, Hore had their bamboos and screw pines cut down; rice, most of the pigs and chickens taken, and the rice houses burnt. But left the living houses and nine-tenths of their rice supply lying outside. When I got back, Hore asked me, as I expected, whether I thought the value of being able to map two marches ahead (fighting our way there) till our "out" rations were finished, was worth the risk of separating ourselves completely from Porter, with Pu-U cliff behind, and with several villages on the warpath between us. As 2 marches ahead would not carry us round the Siyom corner, which is probably opposite Lipung, I told him definitely in my own mind, it certainly did *not*. He then decided to return to join hands with Porter, giving Hamid Gul to-morrow, if fine, to do what more might be possible. This, of course, is a great blow, but as things stand at present it would be madness to push on, and, besides, Dundas particularly told Hore not to risk involving himself so that help

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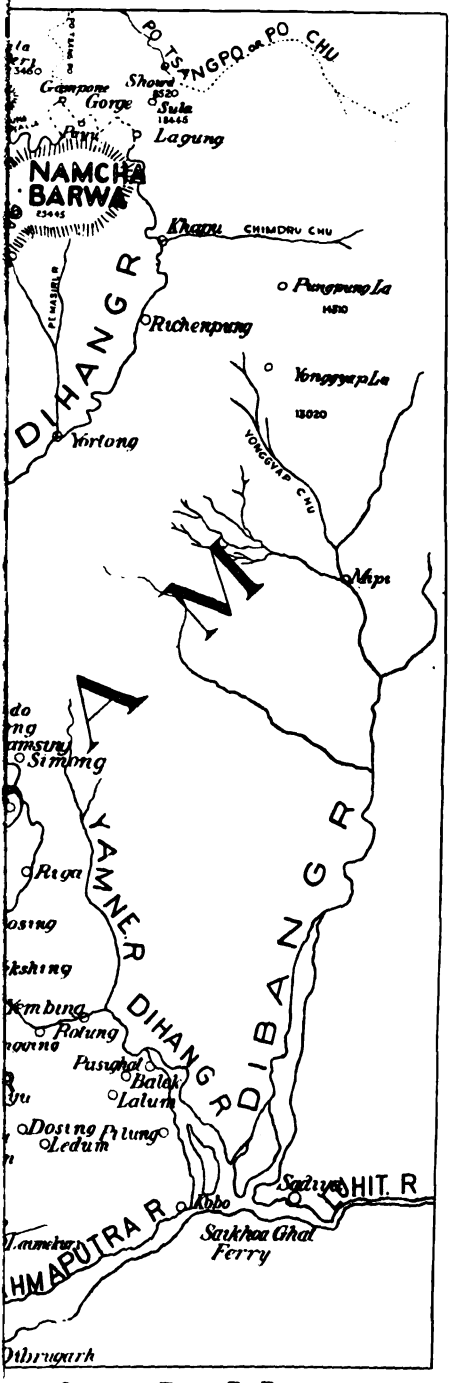
OLITICAL MISSION, 1912-13.



AND GORGE OF TSANG-PO RIVER.

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would have to be sent, as that would delay the more important advance to the falls.

March 30. It seems certain now that the villages ahead will fight, as they have refortified the ravine and Pu-U cliff. The democratic system is a difficulty in this country, as there are always the two parties, the one for peace and the other for war, and in this case the peace party does not seem strong enough to dictate to the rest. Only remains to return. Sickening, but, when all ways and means have been honestly and thoroughly tried, it is no use crying over spilt milk. I doubt if 75 per cent. of the coolies could have got across that cliff with their loads, though these might have been hauled with a rope in one or two places. A Minyong Abor, about 50 yards across, turned quite green and clung to the side and refused to go on.

April 2. Met Bogu *gâms* with a chit from Porter saying the Sike villages are getting uneasy, so it is as well we decided to return. The *gâm* was delighted to find us returning, and on the way back broke into a weird chant. On inquiring its meaning, he told us it was a song of how the *takins* (wild goat-cows) of the hills had once upon a time turned back the elephants of the plains. To which Hore promptly retorted that when the elephants came again next year they would build an elephant road back in Ro Camp.

April 3. Yiyu again. Back nine days earlier than we were expected, but to the intense relief of Porter, who was naturally a little anxious. There is no doubt that Hore tried just far enough and not too far. Most cheery being together again. Cleaned myself. Rain all day.

(*To be continued.*)

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ENGINEER UNITS OF THE OFFICERS' TRAINING CORPS.

By MAJOR D. PORTWAY, Cambridge University O.T.C.

WITH each year showing reductions in the personnel of the Regular Army, and no corresponding reduction of our Imperial commitments, the question of reserves and of replacement of casualties becomes of ever increasing urgency; it is thus that the recognized source of supply of junior officers in Royal Engineer field units for such purposes in an emergency is a matter not without importance. Few officers of the Corps see much of O.T.C. Engineer units, and no details having ever appeared in the *R.E. Journal*, some notes dealing with this topic may be of interest.

The Officers' Training Corps, which was the creation of the late Viscount Haldane, came into being about the year 1907, and, since the recent conversion of Clifton College to Infantry, only the Senior Division possesses Engineer units. These are four in number, there being companies of three sections at Cambridge and at London Universities, Glasgow and Edinburgh Universities each providing a company of two sections. Oxford University had a small unit for two or three years after the War, and this sometimes joined up with Cambridge for its training. It is perhaps a fair criticism of the lack of interest officially taken by the Corps in these units that nowhere do they appear in the Corps List in any shape or form, nor is there any authority for the officers to regard themselves as part of the Royal Engineers (T.A.), although entitled to Engineer pay.

It is a matter for regret that no liaison of any kind is possible between these four O.T.C. units—their camps are held at different times and usually at different places, and doubtless they have developed on somewhat different lines. It is thus probable that each has desirable features that might with advantage be adopted by the others, and perhaps the O.T.C. staff at the War Office, aided by the Inspectorate Branch, might issue useful information on these lines.

The remarks herewith deal, therefore, with one unit alone—that of Cambridge University—and make no attempt to give any account of training methods adopted by the other three.

Recruiting at Cambridge is mainly from undergraduates reading Engineering, though no attempt is made to dissuade those reading other subjects from joining. The fact of a common department and a common academic interest is a unifying influence which other technical units, such as the Signals and Survey, do not possess. The

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two senior officers of the unit are both University Lecturers in Engineering, membership of the Staff of the Engineering department being almost a *sine qua non* for such; the two cadet officers, who are generally appointed, are the most promising undergraduates of the senior years. In connection with the officering of Senior O.T.C. contingents the regulations are those of the Junior contingents, but the circumstances are widely different. Whereas a Headmaster has only to detail an assistant master to a School O.T.C., there is no such equivalent in a University contingent, and the young don shows a marked reluctance to amateur soldiering. The Engineering staff at Cambridge already supplies the O.C. Field Battery, and until recently the O.C. Survey Company, and with no one else showing any desire to carry on the work, the two present officers appear likely to emulate Tennyson's babbling brook as far as their O.T.C. activities are concerned.

Since the War, a marked improvement in the status of cadets of the Senior Division has been made—they are now recognized as officer cadets, they are provided with an officer's pattern uniform, and in all branches are definitely training in the duties of a subaltern officer. It is a corollary of this that recruits to the Senior Division should have already received some training in a Junior contingent, and this is nearly always the case, though of the few who have joined with no previous military experience some are among the keenest and ultimately the most efficient. This improvement of status has been a real advantage—the undergraduate, though light-hearted and not immune from that exuberance so inseparable from congregated youth, reacts in a marked degree to an appeal to his sense of trust and responsibility—a tip which the officers who may be put in future charge of the very excellent course for N.C.O.s of these units in the spring at Chatham will do well to note.

At Cambridge about forty freshmen are enlisted yearly, making the strength of the unit, allowing for wastage, about one hundred. The main working day is perforce Sundays, as week days are fully occupied with work and games, though recruits' lectures and parades are held in the evenings of other days. Equipment has much improved of recent years, and is now fairly ample, and in the first half of the academic year a normal course of field works—mainly bridging, digging and demolitions—is carried out. The number of necessary parades is fifteen, but most cadets considerably exceed this. It is in the second half of the training year that the most interesting term-time work is done, when some permanent construction is always carried out. In 1928, for example, a bridge of 50-foot span for 4-ton axle loads was built over the Great Ouse at Erith on behalf of one of the Colleges; in 1929, several weirs were constructed on the upper reaches of the Granta on behalf of a fishing syndicate, and this year two bridges over the river Stour 25 miles from Cambridge have been built on behalf of

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a nobleman and retired General Officer. One of these, of 45-foot span for 2-ton axle loads, is of R.S.J.s on concrete abutments, with sleeper roadway, the other being a suspension bridge of somewhat greater span for foot passengers; for such undertakings, the Company goes out in motor-buses on Sunday mornings, the arrangement being that the beneficiary pays the cost of stores and transport, with bread, cheese and beer for the workers, plus ten per cent. of the cost for expendable stores, which is a euphemism for a dinner in camp. In addition, the unit undertakes demolitions of a useful nature for colleges and private individuals in preference to the normal demolitions of the rail, girder and wire-rope variety. Many tree stumps have disappeared in the Cambridge district as a result of such activity, but the culminating exploit in this direction was the unwontedly successful demolition of the concrete floor of a former observatory in the garden of a private house, where some tons of concrete spreading over a wide area of the town on a peaceful Sunday afternoon drew a not altogether welcome attention on all sides to the unit's existence. The official ration of explosive is not large, but the gift of a hundredweight of gelignite, by the father of an officer cadet who was a director of a firm making explosives, has done much to supplement the supply through normal channels. Musketry is carried out by every member of the unit in the Easter term, and the unit carries out its full share of the normal military activities of the Corps—tactics, lectures for Certificates A and B, night marching, etc., being carried out under the direction of the Adjutant under Regimental arrangements. A new departure was made a few years ago in appointing a Sapper as Adjutant, and it is hoped that Royal Engineers will in future take their turn with other arms of the Service in filling this appointment.

It is at camp that the most valuable training is carried out, though unfortunately not more than about eighty per cent. of the strength is generally present, rowing at Henley, representing the University at cricket, tennis, swimming or shooting, the taking up of employment by third-year men, all furnishing valid excuses for non-attendance. For many years both before and since the War, the Cambridge contingent has favoured Christchurch (or Mudeford hard by) for camp—training facilities are ideal, and in this connection O.C. Experimental Bridging Establishment has been uniformly helpful, in return for which the unit has been able to provide this officer with working parties for his demonstrations. The adoption of the same place year after year makes for economy, and facilitates arrangements, in addition to which, the near proximity of Bournemouth and the sailing facilities of Christchurch harbour make for popularity and the enjoyment of leisure moments. This feature of a voluntarily enlisted unit is not without importance, especially in the case of Engineers, for whereas readers of literary subjects leave Cambridge from June to October, for most engineering men the O.T.C. camp spans almost the

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whole vacation between the end of May Week and the beginning of the Long Vacation term, when they return to work in Cambridge.

Training at camp is largely devoted to bridging, but drill and engineering schemes are not omitted, and visits are always paid to the Tank Corps Depot, who always stage an admirable demonstration, and alternatively to the Air Force at Old Sarum, where the Cambridge University Air Squadron is in camp, and the R.E. Pontooning Camp at Wyke Regis. Some new feature is usually included in camp, this year's change being night operations, wherein the opposing forces were taken down the river in pontoons driven by outboard motors.

In conclusion, the question arises as to whether these units are adequately fulfilling their functions. These are two in number: (*a*) the supply of the Territorial Army and Supplementary Reserve with officers in time of peace, and (*b*) the provision of officers for the Army in time of war. As regards the latter, there is no doubt at all —these units produce officer-cadets, nearly all of whom have acquired at the end of their three years a reasonable proficiency in military engineering, and who would join up to a man in a national emergency. As regards the former, the number who go on to Territorial and Supplementary Reserve units is frankly disappointing. This is mainly due to the exigencies of the engineering profession, wherein two years' post-graduate workshop practice is demanded before a student is qualified, and during which it is rarely possible for a commission to be taken up. It is a subject of some difficulty, not less so owing to the dislike of the generality of young Englishmen to peruse anything in the nature of an official publication, but if a pamphlet rather on the lines of the recently issued "General guide to a commission in His Majesty's land forces," but solely containing the necessary R.E. information in considerably greater detail, were drawn up, it would be of considerable use. It should contain the places where Supplementary Reserve and T.A. Engineers units are stationed, and a supply should be available for the use of O.T.C. Engineer unit commanders, who would doubtless give a copy to every man on leaving his unit, and in reply to the not infrequent enquiries that are now received. There is little doubt that excellent field-unit subalterns are available to fill present shortages—men who would do the job well and would enjoy the work if they but realized how to set about obtaining the appointment, and more careful staff work might do something to retrieve some of the valuable material for officering the auxiliary forces that is at present wasted.

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SOME OUT-OF-THE-WAY PLACES.

By LIEUT.-COLONEL L. E. HOPKINS, D.S.O., O.B.E.

I.—Diarbakr.

THE country of Abubakr the Caliph, and the town of the same name, is now less remote than when I visited it in 1903, but it appears to be quite as little known as it was then. There appears to be no more recent information about the place than 1910, and even that does not seem to be fresh, and the only news is that there is no longer a British Consul there. It would be possible nowadays to reach the town by car from the Bagdad Railway in a day, but in 1903 it took me thirteen marches from Alexandretta, averaging 25 miles a day.

Diarbakr is chiefly remarkable for its Roman walls of black basalt, which are in an excellent state of preservation. There are a few buildings outside the Northern Gate, but approaching the town from the west there is not a sign or sound of habitation, and it is difficult to believe that a town of 40,000 people, which Photograph 1 shows, lies just behind the sinister black walls. Photograph 2 shows the walls above the Tigris on the east side of the town. The river can be just seen on the right of the picture.

The walls were built in their present form, so it is said, by Constantine in the 4th century. The curtain walls are 50 feet high, and the towers which stand out in front of them are some feet higher than the curtain. The place was considered one of the worst frontier stations of the Roman army, but is a paradise compared with some British frontier stations. When Shapur attacked the town, it was garrisoned by two legions sent from Gaul for insubordination. Khosru, Saladin, and Taimur, among others less famous, are said to have besieged the place. Thirty years ago it used to be considered a place of strategic importance, the key to Mesopotamia and of the approach to the Mediterranean, which Russia might be supposed to covet. The town, standing high above the Tigris on a great cultivated plain stretching away to the snow-covered Karajah Dagh on the west, seemed in those days to provide an ideal site for a great military centre. Like much of Asiatic Turkey, the country is bare of trees, and firewood is brought from the hills some distance north.

The third photograph shows the raft on which we floated down to Bagdad 500 miles downstream, an exciting journey, as far as Jezireh, through the gorges and rapids. The bridge shown is the old Roman bridge just below Diarbakr.

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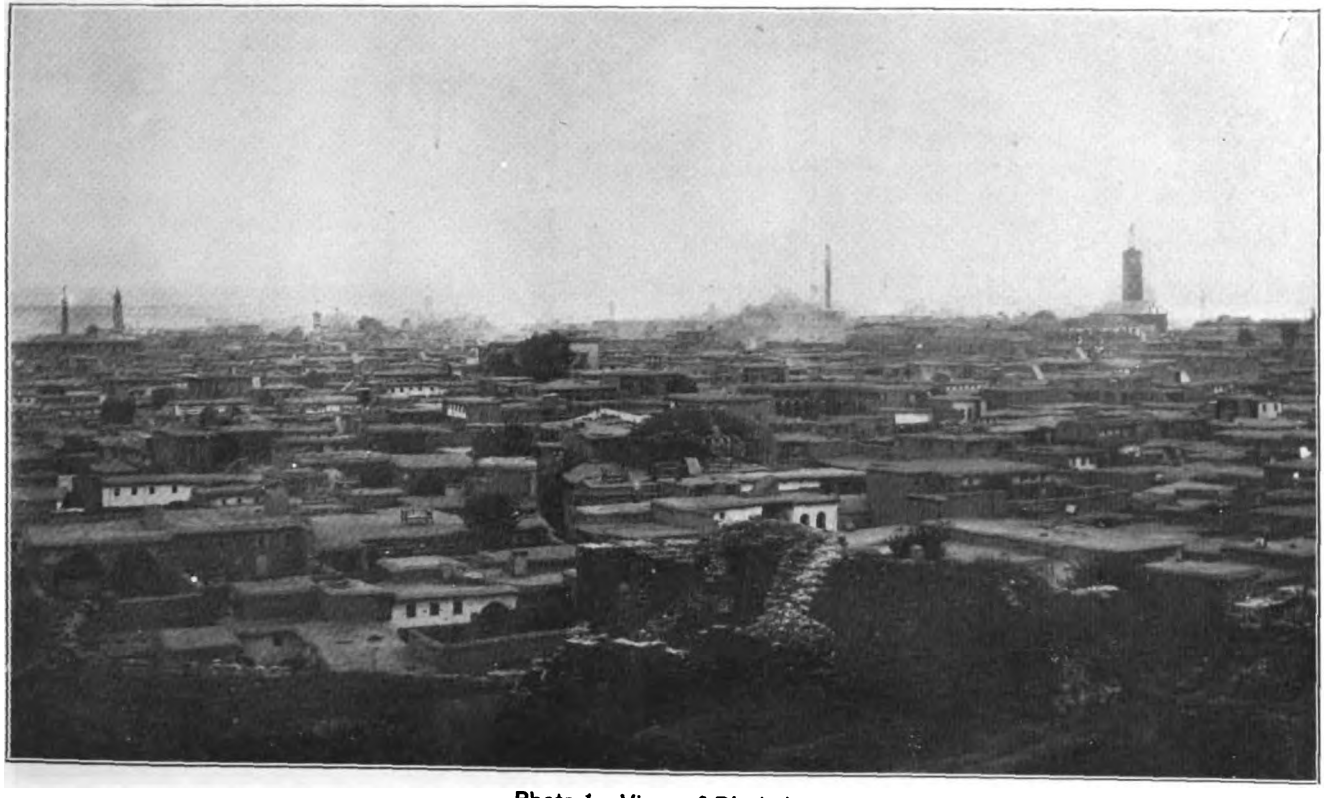

Photo 1.—View of Diarbakr.

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DIARBAKR.

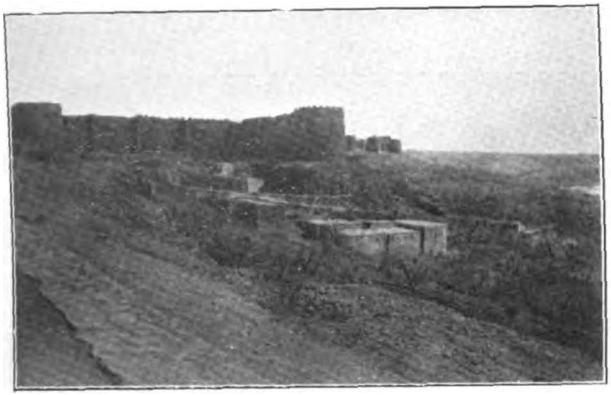
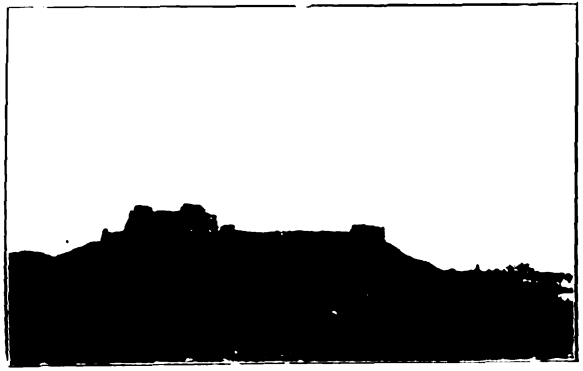


Photo 2 Roman Walls.

DIARBAKR.

Photo 3. Raft on Tigris Roman Bridge.

BAMPUR.



BAMPUR.

Photo 5.— Persian Baluchis.

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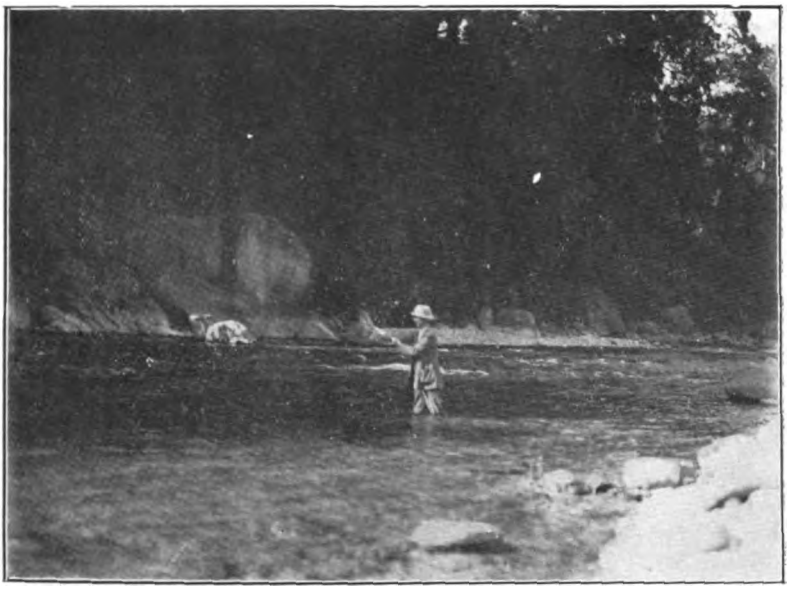

Photo 6.—Mahseer Fishing near Road to Khatmandu.

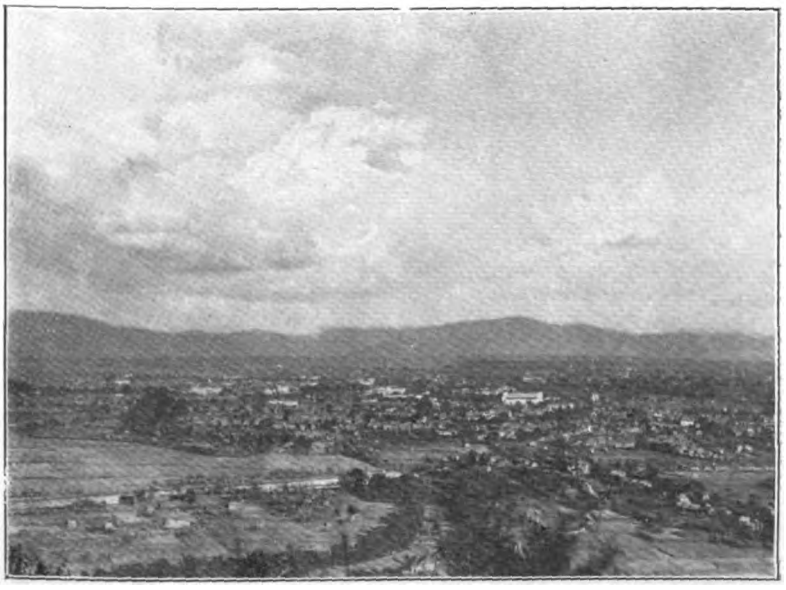

Photo 7.—Khatmandu. Capital of Nepal.

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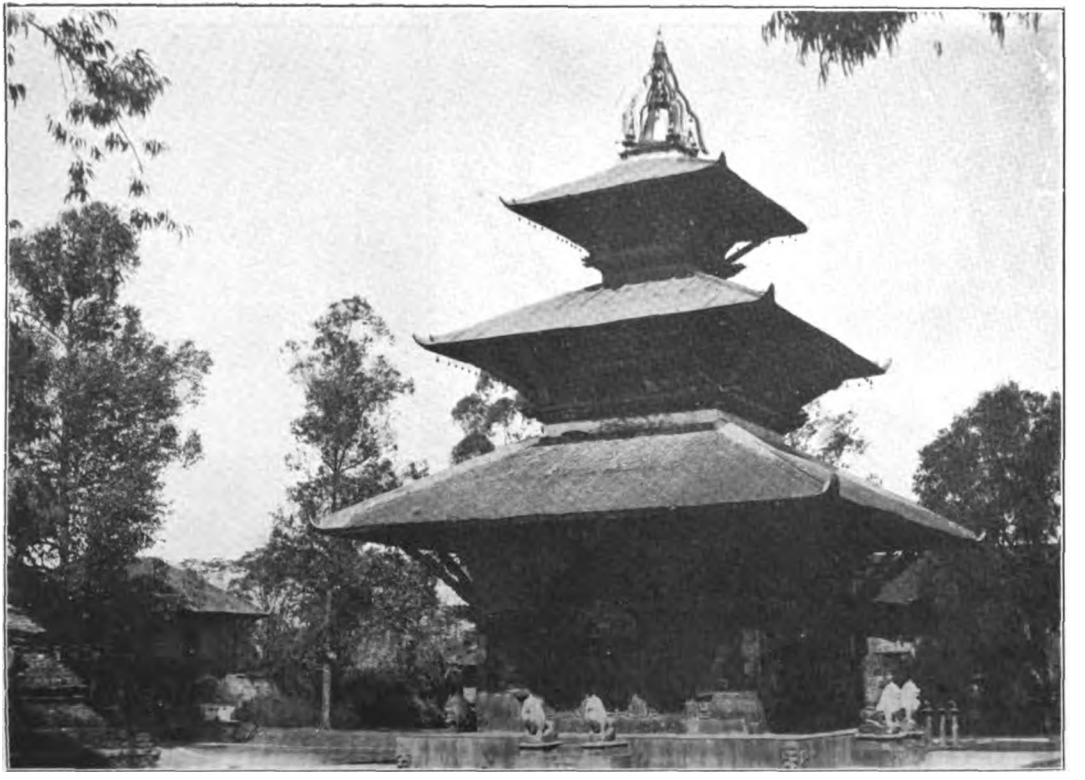

Photo 8.—Temple in Old Khatmandu (Patan).

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The streets of the town are paved with stone, but are so narrow that the Governor's phæton had to be handled round corners. Houses show a blank wall to the street, through which a small iron-studded door admits to a courtyard overlooked by a raised verandah, and containing perhaps one or two orange trees. The inns were primitive and verminous, but good food obtainable, and everywhere the most excellent coffee and cigarettes and that delightful liqueur of which M. Catoni, our Consul at Alexandretta, possessed an excellent brew. Distilled from grapes and flavoured with aniseed, it has the taste of Kümmel and the consistency of vodka. It was known as Mastic, if I remember right. At that time in Turkey, it was not good form to drink alcohol in public, but it was always offered to Christians in a furtive sort of way, and it was understood that Turks were not fanatic prohibitionists in their own homes.

Certainly the Turks I met in those days were good fellows. Big, jolly, and frank, they were the gentlemen of the country, and I have the pleasantest recollections of them. The Turks stood out obviously among Jews, Arabs, Kurds, Armenians and Persians and the numerous Christian Sects, as the ruling race of the country. It is to be hoped that they are not making a mistake in turning to modernism and throwing away the traditions of their race.

Good food is to be had everywhere in Turkey and Persia, in great contrast to Hindustan, a country which Babar speaks of in his Journals with great contempt, because of its lack of good cheer, hospitality and the carousing of which he was perhaps too fond.

I stayed at Karabagche, a peculiar village on the last stage before reaching Diarbakr, peculiar because the whole village lives under one roof nearly 100 yards across. I suppose it was so built for warmth in winter. Our horses occupied the entrance, the eyes of cattle could be seen glowing down a dark passage to the left, and on the right our men shared a room with a camel. My room, however, was clean, and round the sides were thick felt rugs, and a fine charcoal fire in the centre. The only ventilation and light was admitted through two holes in the flat roof.

II.—Bampur.

This is nominally the headquarters of Persian authority in Persian Baluchistan, but practically it is seldom visited by any Persian. It is too far from civilized Persia, and the true Persian does not care for the lowlands below 5,000 feet above M.S.L. Syed Khan of Geh, a local chief, was nominally governor on behalf of Persia when I visited the place in 1912 and 1913, but at that time every valley in the surrounding hills had its own Khan and all of them are practically independent. They are a wild highland breed.

There is no town or village at Bampur; nothing but the fort,

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built of sun-dried bricks, which, as can be seen in Photo 4, is quite imposing. The fort, too, is uninhabited except by a few *chokidars*, who had a shot at me when I was passing on my way north. It appeared, on enquiry, to be a case of nerves. It must have been nervous work for a few men living in a fort big enough for a battalion. There is another fort about 20 miles east at Farah, which another Khan had at that time recently seized and was giving Syed Khan a good deal of anxiety. Small wars are always in progress in that part of the world. The people are primitive but not uninteresting or uncivilized. They have a good deal of Persian polish and manner.

The governor usually spends the spring at Bampur, camped in the fields, and at that time the climate is very pleasant, but as a rule he lives in his fort at Geh, in the mountains, half-way to the Persian Gulf. There is a stream, from the hills in the east, which flows through the Bampur Plain and into the Jaz Morian Hamun and along it a belt of cultivation half a mile wide, in which and among the thorn trees there is the best black partridge shooting I have ever had.

Away from the cultivation the usual sandy plain rises slowly to the hills 20 miles south, the summit of which is about 5,000 feet above the sea along the Makran Coast. Forty miles to the north is the volcanic peak, the Kuh Bazman, which rises to about 11,000 feet above the sea.

There are four principal mountain gorges by which Bampur is approached from the Makran Coast, and it will be a long time before a motor finds its way up there. Perhaps through Fanoch it could be done, perhaps it has already been done. But it would not be impossible to reach Bampur from the north by car. From Bander Abbas it would also be practicable; except for the 20 miles up the Minab river, the rest is plain sailing.

All along the south side of the Hamun-i-Jaz Morian is an immense cultivable plain, hardly inhabited at all. There are many ruins of towns at the western end, and the few nomad inhabitants are a very interesting race of fair-haired European type, obviously the remains of some old Greek invasion. They are fine, big men, and in their black frock coats and high felt hats look very modern and a great contrast to the wiry aboriginals of the Hills along the Makran Coast, with their robber chieftains of probably Arab descent.

III.—Khatmandu.

In 1926, the Government of Nepal was contemplating the construction of a light railway as far as possible towards the capital, and my services were lent to the Maharajah to advise on the project. As no person not a Nepalese is allowed to enter Nepal without the

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Maharajah's permission, I was very glad of this opportunity to see a country which few have visited and which was reported to be extremely inaccessible. The report is certainly not exaggerated. I have never been over a worse road. The 20 miles from the railway to the foot of the Himalayas is covered by motor, and for a further 20 miles into the hills there is a good cart road, which has probably by this time been completed for motor traffic. Alongside the road is one of those delightful Himalayan rivers, clear and blue and foaming over white boulders and sand. Those whose only experience of fishing is in the dismal rivers of England or Scotland, have a new pleasure before them in these Himalayan streams. They are full of the "mighty *mahseer*," which is a better sporting fish than salmon or trout, and there are several other kinds of fish which take a fly. (Photo 6).

The second day's march ends with a steep ascent of 2,000 feet to a fort and rest-house. There is no attempt to grade the path which goes straight up the hill at an angle of about 45°. We were carried up this hill in chairs and one felt it would be safer on the ground than on the shoulders of the carriers.

The third march descends 2,000 feet and then gradually rises to a summit about 7,000 feet above M.S.L. From there the path descends 2,000 feet to the Khatmandu Valley, down what is practically a stone staircase through the forest. We were met at the foot of the hills by the Maharajah's big Hudson car and soon covered the 10 miles into the capital. This car, we were told, was carried into the country lashed to a framework of poles on the heads of 64 carriers, who must have had a difficult task in negotiating the two passes.

Khatmandu, as may be seen in Photograph 7, lies in a delightful valley. It is about 4,000 feet above M.S.L. The town is a strange mixture of mediævalism and fine modern buildings, which would suit Clive Street, Calcutta. The Maharajah's palace is on the scale of Buckingham Palace. The houses of the nobles are hidden in large gardens surrounded by walls of red brick about 16 feet high. Nepalese troops were to be seen drilling in thousands on the large parade grounds or marching on the roads in the neighbourhood.

There are several old towns which were former capitals and now only half-occupied. They seem to consist largely of temples of the type shown in Photograph 8. It is said that the pagoda type of roof originated in Nepal. The houses are all well built of red brick, usually three stories high. The Nepalese are short men and the height of the rooms is made to suit them, giving the three stories a dwarfed appearance. One remembers the Gurkha trenches in France, which were built on the same scale as these houses.

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"PINKING."

By CAPTAIN K. A. LINDSAY, R.E.

A CONSIDERABLE amount of research has been carried out during the last few years, to investigate the causes of pinking in internal combustion engines, and with the advent of the highly efficient modern automobile engine, the prevention of this undesirable feature is extremely important.

The sound known as "pinking" must be familiar to many car drivers, but it may be as well to point out that a good example is that given by an old type L.G.O.C. bus, starting off fully loaded, and can be defined as a distinct metallic "knock" not due to any mechanical defect. Apart from the unpleasant noise, "pinking" is very liable to affect the lubrication of an engine, owing to the rupturing of the oil-film in the bearings by the very rapid rise in pressure.

It is a very common fallacy to confuse pre-ignition with "pinking," and it has often been suggested that they are one and the same thing. Pre-ignition in a petrol engine, as its name implies, is the firing of the charge before the pre-determined moment; it generally occurs in an engine requiring decarbonizing, when the charge is exploded by the incandescent carbon deposit. However, the trained ear can easily distinguish between the dull "clonk" of pre-ignition and the sharp metallic sound of "pinking." In addition, it has been proved experimentally by Ricardo,* that "pinking" occurs *late* in the firing stroke. It is, however, true that sustained "pinking" will quickly lead to pre-ignition, which in turn may lead to the complete shut-down of the engine.

The only practical way to stop "pinking" in a given engine, using a specific fuel, is to reduce the load, and, therefore, the mean effective pressure. The design of engines for automobiles and aircraft is confined to certain limits as regards cylinder dimensions; the R.A.C. rating influences the former, while the desirability of the maximum horse-power per lb. weight governs the latter. The highest possible M.E.P. is therefore required, and the elimination of pinking is of the greatest importance.

From the economic point of view also, the highest efficiency is desirable. The first method which strikes the mind of the engineer for increasing the efficiency of an engine is to raise the compression ratio, and, up to 6 to 1, a modern high-speed petrol engine of normal

* *Engineering*, March 18th, 1927.

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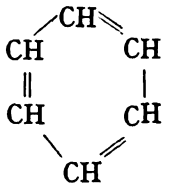
bore can be run satisfactorily. Above this, however, experience proves that, without doped fuel, "pinking" will result on full throttle.

There is, therefore, no doubt that the future development of the internal combustion engine must depend largely on the extent to which the problems connected with "pinking" are overcome. Scientists are still in controversy over the phenomenon, and it is outside the scope of these notes to delve deeply into the chemical side of the problem, but it is hoped that the following compilation will shed some light on a rather obscure subject.

It can be shown theoretically and practically that the thermal efficiency of an engine increases with the compression ratio, but the liability to "pink" of the fuel used must limit this ratio.

It has been found, as a general rule, that alcohol and the aromatics or ring compounds, such as benzene (C_6H_6) of the form :—



are very much less liable in this respect than the "paraffin" series or chain compounds, such as Heptane (C_7H_{16}) of the form :— CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3.

Particulars relating to these fuels are given in the table on the following page.

Before passing on to dopes or special fuels, the importance of alcohol and benzene (commercially known as benzol), for military purposes should be pointed out. Both these fuels can be produced in the British Isles, both are good non-pinkers, and the former is particularly suitable for air-cooled high-speed engines.

Experiments in the past have shown that certain substances, sometimes discovered accidentally, considerably diminish "pinking." Both exhaust gases and steam mixed with the charge are very efficient in this respect, a difference of $\pm$ 17 per cent. by weight of exhaust gases will lower or raise the flame temperature 25°, equivalent to a range of compression of from 4 : 1 to 5 : 1.

In 1922, Midgley and Boyd carried out certain experiments, using their bouncing-pin method for determining the "pinking" characteristics of fuels. The apparatus consisted of a steel pin resting on a diaphragm fixed in the cylinder-head of an engine ; the effect of "pinking" was to bounce the pin, which touched electrical contacts, thereby recording the degree of "pinking."

Working on an apparently erroneous hypothesis, they tried the addition of iodine and bromine to the fuel, with the result that the

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Fuel.	*% by weight.*		*Specific gravity.*	*Air/fuel ratio by weight.*	*Calorific value lb. cals. per lb.*	*Highest useful compression ratio.*	*Temperature of initial combustion.*	*Ignition Temperature.*	*Remarks.*
	C	*H*					C	C	
PARAFFINS (C_nH_{2n+2})									
Hexane (C_6H_{14})	83·7	16·3	0·67	15·3	10,760	5·1	266	450	Compression Ratio figures were obtained by means of a Ricardo variable compression engine.
Heptane (C_7H_{16}) ...	84·0	16·0	0·69	15·2	10,680	3·75	240	—	
AROMATICS (C_nH_{2n-6})									
Benzene (C_6H_6) ...	92·3	7·7	0·88	13·2	9,710	6·9	670	520	Temperature of initial combustion is the temperature at which oxidization commences under normal conditions.
Tolvene (C_7H_8) ...	91·3	8·7	0·87	13·4	9,810	7·0	550	516	
Xylene (C_8H_{10}) ...	90·5	9·5	0·86	13·6	9,980	7·0	540	500	
ALCOHOL. ETHER.									
Ethyl Al (C_2H_5OH)	52·2	13·0	0·80	8·9	6,560	7·5	520	510	Ignition temperature is the lowest temperature at which inflammation will start under normal conditions.
Ether $(C_2H_5)_2O$ ...	64·9	13·5	0·74	11·1	9,340	3·9	—	—	

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former diminished " pinking," while the latter had the reverse effect.

They then proceeded to experiment with nearly every chemical substance, finding several with the required properties, lead tetra-ethyl amongst others.

Much work has been carried out since, both in Europe and America, and the three best " dopes " discovered up to the present are, lead ethyl, and carbonyls of nickel and iron ; unfortunately all three are poisonous.

Certain substances, it should be noted, have exactly the reverse action to dopes, and, if drawn in with the charge, can cause such excessive " pinking " as to necessitate stopping the engine. Benzoyl peroxide $(C_6H_5Co)_2O_2$, is one of the best examples of these knock-inducers.

If a suitable method could be devised for carrying any of these substances in a gas cloud, it is not outside the bounds of possibility that an advance of enemy tanks could be stopped by these means, if the necessary concentration could be obtained.

It is only within the last few years that the phenomenon of " pinking " has been studied to any great extent, but during this time many hypotheses have been put forward.

Before examining these, it will be as well to consider the usual circumstances under which " pinking " develops.

These can be summarized as follows :—

Pinking is prevalent :—

(i) *Fuel.* With the paraffin series as opposed to the aromatic series.

(ii) *Speed.* With low engine speed.

(iii) *Design.* With a combustion chamber having a high compression ratio, containing pockets, and with a long flame travel.

(iv) *Carbon deposit.* When decarbonizing is necessary.

(v) *Ignition.* With an advanced spark.

In addition to dealing with the above, any satisfactory hypothesis should also explain the anti-knock action of steam, exhaust gases, and other " dopes."

About fourteen different hypotheses have been evolved to explain " pinking," but it will be sufficient to describe only six of them, showing their reasoning as regards certain phenomena, and how they fall short in the explanation of others.

1. DETONATION. The explanation generally accepted amongst engineers until recently was that " pinking " and detonation were synonymous. The symptoms are certainly very similar, but experiments by Egerton and Gates have disproved the idea. The latter

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have shown that neither lead tetra-ethyl nor nickel carbonyl, which stop "pinking," have any marked effect on detonation, while increased compression, which causes "pinking," slightly lessens detonation.

In addition, it appears unlikely that a detonation wave, which has a definite period of evolution, could develop in the confined space of a small cylinder.

2. Two Frenchmen, named Jolibois and Normand, pointed out that sharp edges in the combustion chamber tend to accelerate the flame velocity; this is true, and it is also possible that colloidal lead, as they suggested, deposited on these edges might counteract their effect. But it has been shown that knocking begins at once if a pinking fuel is substituted for a doped one, even though the lead is still present on the surface of the combustion chamber.

3. Three Americans, named Church, Mack, and Boord, having noted the effect of multiple spark-plugs on "pinking" in a cylinder, put forward the idea that the very fine particles of anti-knock metal undergo such rapid oxidization as to develop sufficient heat to raise them momentarily much above the temperature of the yet unburnt gases in which they are present. They, therefore, become incandescent and function as multiple miniature sparking plugs.

This hypothesis does not explain the action of knock-inducers.

4. Wendt and Grimm suggested that electrons are emitted from the reacting molecules in the flame, and that these electrons ionize and activate the unburnt molecules, causing detonation.

If this hypothesis were correct, the "pinking" would be affected by a magnetic field; this has been tried experimentally and disproved.

5. Another hypothesis, a German one, supposes that the primary factor in "pinking" is *electrical non-conductivity*, the higher the conductivity of a fuel, the less is the liability to knock. It is assumed that if the fuel is a perfect insulator, such as benzene, it will become electrically charged by friction with the inlet pipe, when rapidly drawn into the cylinder on the induction stroke. Differences in potential therefore arise, which are further accentuated by compression. When the gas mixture is fired, the combustion is too quickly accelerated, thus giving rise to knock. If, however, the fuel is conductive, as benzene, for example, there are no electrical disturbances, and ignition takes place normally.

This hypothesis is difficult to confute, and certainly satisfies several phenomena, including the anti-pinking action of metallic dopes. However, research based on it, carried out in Germany, has not met so far with any great success.

6. It now remains to explicate Callender's nuclear drop hypothesis.

It has already been stated that Ricardo proved that "pinking"

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develops late in the firing stroke ; which suggests that " pinking " is due to a sudden rapid burning of the unburnt charge, and Callender proceeded to investigate the cause of this.

It is an experimental fact that whereas steam and alcohol vapour get drier when compressed, petrol and benzol vapour tend to fog, while the vapour of the paraffin series develops minute droplets which grow bigger as the pressure rises and do not evaporate as one would expect. The evaporation of these drops is further prohibited by the short period of the compression stroke. A test with Shell aviation spirit showed that with an 8 : 1 ratio, 50% of the fuel was present in the form of liquid drops.

A colleague of Callender's, Dr. Mardles, now suggested that in some way the partial oxidization of the fuel might act as a detonator, and cause the droplets to burn towards the end of the firing stroke.

Tests were carried out on a variable compression engine, by starting up normally, switching off, and continuing running the engine driven by an electric motor. Peroxides were traced in the exhaust under conditions when " pinking " would normally occur, and not otherwise.

A further series of experiments was carried out in which mixtures of fuel and air were passed through quartz tubes in a furnace and burnt. Through one tube a fully vaporized mixture was passed which burnt with a steady flame. Through another tube a fine spray of fuel with air was passed ; in this case intermittent flashes were seen, which, in view of Dr. Mardles' hypothesis, suggested the ignition of the peroxides present on the surface of the drops. The addition of lead ethyl stopped both the formation of the peroxides and the flashes, while the addition of amyl nitrate, a knock-inducer, increased the phenomena.

Another fact, which appears to have some connection, is tha tall fuels liable to " pink " have a temperature of initial combustion much lower than the ignition temperature (*vide* table on p. 686). It appears likely, therefore, that the peroxides form during the compression stroke with " pinking " fuels, owing to the low temperature of initial oxidization.

Callender therefore concluded that " pinking " is due to the accumulation of peroxides in liquid drops during compression. These peroxides act as primers, causing the very rapid inflammation of the droplets.

It is certainly difficult to disprove this hypothesis, and referring to page 687, it appears to bear out the phenomena enumerated there:

(i) *Fuel.* The paraffin series has a low temperature of initial combustion compared with that of the aromatic series.

(ii) *Speed.* With a high engine speed it is fair to assume that there will be less time for the peroxides to form.

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(iii) *Design.* A combustion chamber with a high compression ratio and pockets will assist the formation of droplets.

(iv) *Carbon deposit.* When decarbonizing is necessary, the compression ratio is increased.

(v) *Ignition.* The effect on " pinking " of retarding the spark is difficult to explain. It is possible, however, that owing to the period of flame travel being shorter, there is not sufficient time for the vibrating effect to be produced.*

During the period that Callender was carrying out his experiments at the Air Ministry Laboratory at the Imperial College, other scientists were arriving independently at very similar conclusions, and, although they do not agree on all points, it is possible to compile a working hypothesis, which may be useful to the engineer during the period which must necessarily elapse before a theory can be evolved by the experts.

This hypothesis is as follows :—

During the compression stroke, the fuel in the cylinder undergoes a certain amount of oxidization, the degree of oxidization depending on the comparative temperatures of initial combustion and ignition of the particular fuel.

Late in the firing stroke, when the temperature and pressure have fallen, the peroxides are reduced and ignite the unburnt fuel.

The inequalities in the state of the charge give rise to irregularities in burning, which result in a vibratory condition of flame.

A wave of compression is started, which rebounds from the cylinder walls and travels through the products of combustion and unburnt gases, producing a knock late in the firing stroke.

The action of anti-pinking dopes is either to reduce the peroxides as fast as they form or to prevent their formation, thereby keeping the mixture uniform, and resulting in a steady burning during the firing stroke.

In conclusion, it is quite possible that more than one action may cause " pinking," and that, in addition to the last hypothesis, the electrical conductivity of the fuel may play an important part.

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OFFICE ORGANIZATION IN A SMALL UNIT.

By LIEUTENANT A. J. KNOTT, R.E.

IN these days of big ideas of military training, strategy and such subjects, criticism may perhaps be directed at this article on the grounds that it is wasting space and the time of those who read it, both of which might more profitably be given up to less trivial matters. The reply to such criticism is the old adage, " Look after the pence and the pounds will look after themselves " ; in other words, pay a little more attention to such trivial matters as office work and the small details of administration, and there will be more time and energy available for the consideration of the bigger things. No officer wishes to be chained to an office stool more than is absolutely necessary, but as things are at present, there are only two courses open to many officers who are responsible for offices ; either they *must* spend a very large part of their time in the office, doing what is mainly clerks' work, or they must leave the office to run itself. If they choose the latter alternative they may be lucky, and avoid serious trouble, but it is far more likely that, sooner or later, they will be caught out by a complete breakdown of the office organization at some important moment, resulting in a large " raspberry " for them.

Before proceeding any further, let it be quite clear what type of offices is intended to be covered by the remarks in this article ; those of approximately the size and capacity of that of a Field Company are the primary object of discussion, though the suggestions offered may be equally applicable to offices of other small units ; they are definitely not intended to apply to Headquarter Offices and similar institutions, where, presumably, the organization is more permanent and therefore less liable to dislocation.

The Field Company suffers more or less permanently from a shortage of really good clerks. Occasionally there comes a period of bliss, when a first-class clerk finds his way into a small unit for a time, but it is not to be expected that he should stay long ; either he is wafted away to some bigger job, or his time with the Colours expires. It often happens, too, that the best clerk in such a unit is a man who is not a clerk by trade at all, but a carpenter or other tradesman ; in this case, it is not fair on him to keep him in the office permanently ; he must be given the opportunity to improve, or at any rate maintain, his trade efficiency. The " rate of flow " of N.C.O.s and men through

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a Field Unit is surprisingly rapid, and it is necessary always to be prepared to have any or all of one's office staff whisked away at short notice. These considerations make it clear that lack of continuity and a not too high standard of individual efficiency have got to be taken into account by officers in charge of small offices. This fact being recognized, it is all the more important not to rely too much on any one individual or set of individuals.

Although considerations of peace-time training are uppermost in a question of this sort, it must not be forgotten that the office of, for instance, a Field Company has to function to a considerable extent in war. On active service it is more essential than ever that constant supervision of details by officers should be unnecessary, and that no individual should become in any respect indispensable. In war, routine work will certainly not disappear altogether; the issuing of orders, etc., will entail work on the part of the office staff that it does not normally perform in peace, but in which a certain amount of practice may be obtained in manœuvres and other operations. Really sound training of the personnel of small office staffs is therefore essential, just as much as of the actual fighting troops, in order that they may carry out their duties satisfactorily in war. A fool-proof organization is also necessary in order that casualties may not seriously dislocate the system. This state of affairs can only be arrived at by ensuring that, in peace-time, the whole organization is so cut and dried that, firstly, it will run without constant supervision on the part of an officer and, secondly, that the duties of each individual are so detailed that any N.C.O. or man of average intelligence can perform them satisfactorily without long practice.

Let us now consider the various individuals who make up the office staff. Normally, these will be the C.S.M., C.Q.M.S., Pay N.C.O. and assistants to each of these according to individual requirements. The number, rank and duties of these assistants will be considered later; let us take the principals first. How many officers are there who, when faced with a letter or problem which requires an answer, can say without hesitation which member of his office staff will have to deal with the various stages through which the reply must pass before it reaches its destination? There must be many who do not trouble themselves about this at all, who draft the answer in their own hand, put it in their "Out" tray, and hope for the best. Then, if there is a clerical error, or the letter goes to the wrong person, they cannot really know whom to blame; their only course of action is to send for the Serjeant-Major, and take it out of him, though he may be absolutely innocent. If there were a sound office organization, with which the officer was fully conversant, he would be able to go straight for the man who was really responsible for the mistake.

The position of the Company Serjeant-Major merits some consideration. It is sometimes the case in peace that he spends a large part

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of his time in the office, particularly if he is by nature clerically minded. This will not be possible in war, and even if it were possible, it would be most undesirable. The C.S.M.'s duty is to be " out and about " ; there will always be a hundred-and-one things which require his attention, and if he is constantly hampered by the knowledge that the office work cannot go on properly without him, he cannot be expected to see to them. This principle applies equally in peace, so let the peace-time organization of the office be such that the C.S.M. does not play any very vital part in it. Certain returns, states, etc., and Daily Orders (Part I) are his job, and his alone ; apart from these, he should not be in any way an essential part in the mechanism of the office.

The next essential member of a small office staff is the Pay N.C.O. He is really the most highly-specialized person in the office, and often the hardest to replace. Although he often has friends at hand whose advice he can ask, he must be fully acquainted with all the details of his always tricky job. Good accountants are not easily come by, and, once discovered, are not lightly to be given up. No one, however, is indispensable, and some arrangement must be made to replace this specialist in the event of his going sick or leaving the unit. *R.E. Corps Memo.* states that there should always be a N.C.O. under instruction in Pay duties, and proficiency in these duties is a valuable qualification for any N.C.O. to hold. It is, therefore, advisable to ensure that there is always at least one N.C.O. in a unit trained in Pay duties, in addition to the actual Accountant, and if there is not one already trained, to get and keep one under instruction. A learner in the office is distinctly valuable, as it is seldom easy to arrange for a man to come into the office from outside at a moment's notice.

The work of a Pay Accountant is by no means light, and with the London system of accounting the volume of work to be got through at the end of each month assumes no small proportions, and will usually entail the sacrifice of considerable spare time if it is to be done conscientiously. It is not easy to add or check figures with other people constantly walking in and out of the office, or discussing football and other extraneous subjects ; for this reason, many Pay Accountants are compelled to leave much of their work till the evening or the week-end. No officer would willingly condemn any of his N.C.O.s to evening or week-end work when it could be avoided, and, though it may not often be possible to give the Pay N.C.O. an office to himself, even a quiet corner in the main clerks' office, away from the hum of the ordinary day's work, will be of considerable benefit, and save an appreciable amount of time on the monotonous job of adding figures and balancing accounts.

Although in the majority of cases he works in a separate office, the C.Q.M.S. is just as much a part of the office staff as any of the others. In order to obtain that appointment, a N.C.O. has

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to be certified by his Commanding Officer as qualified in the duties thereof. In spite of this, many N.C.O.s, particularly those on the Mounted Roster who become C.Q.M.S.s of Field Units, are not clerically-minded at all, and find ledgers and similar accounts very difficult to master at first. Is it fair, then, to expect them to take over and perform efficiently a job which they have never done before and which at best is not easy, and may well become most tricky and complicated, without some assistance? If the unit in question is the only one of its kind in a station, the C.Q.M.S. requires more knowledge of the details of his job than if there are others of his calling at hand whose advice he can ask. In any case he will learn more quickly, and forget less easily, if he has to find things out for himself, than if he can always go next door and be told the answers to his daily problems; besides, no two problems are exactly alike, and the answer which may have solved his neighbour's problem perfectly may not be the right one for his own conundrum.

The work of the C.Q.M.S.'s department may be divided into two parts: outdoor work, looking after quarters, personal interviews with R.A.S.C. and R.A.O.C. (which are so much more effective than any amount of writing), repairs to barracks, etc., and indoor or office work, checking vouchers, making out indents, posting up ledgers, etc. If a C.Q.M.S. is to attend to his outdoor work really thoroughly, it is only reasonable to provide him with someone in the office who can carry out purely routine duties, such as checking packages or making out returns. These duties, although they may sound quite easy, are beyond the powers of many men, and the C.Q.M.S.'s assistant will become a menace instead of a help unless he is a man of real intelligence, who has some education and is neat and methodical. Given such assistance, there is no reason why the "Q" side of a small unit should ever go seriously wrong; without it, the C.Q.M.S. is apt to become genuinely overworked and, with the best of intentions, will almost certainly let his officer down sooner or later.

Returning for a moment to the case of a unit which is by itself, or indeed in any station where there is no Quartermaster or R.Q.M.S., the C.Q.M.S. may be called upon to perform the duties of either or both of these. He cannot then be expected to carry out his own company duties and those of the R.Q.M.S. efficiently and conscientiously. There are two possible solutions to a situation of this sort; either the C.Q.M.S. may be given an increased staff but made to retain the whole responsibility, when he must do his best to keep an eye on all the varied activities of the members of this increased staff, or the work may be divided into two distinct parts, one under the C.Q.M.S. himself, the other under a selected senior N.C.O. The decision between these two alternatives must depend largely on circumstances and individuals. If the C.Q.M.S. is an exceptionally capable man, he may be able to exercise sufficient supervision over

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two or three assistants, and so keep the show running well, but there are not very many men who can do this, and the responsibility is large. Bearing in mind the fact that training in C.Q.M.S. duties is valuable for any senior N.C.O., it will more often be found advisable to create two separate departments, each with its own staff and, if possible, its own office. If this is done, the cut must be complete and decisive, and it is not difficult to arrive at a logical and fair division of labour. A suggested allotment is to make the C.Q.M.S. responsible for all matters involving the R.A.S.C. (Barracks, Supply and Transport), while the senior N.C.O. deals with all questions concerning the R.A.O.C. (clothing, equipment, etc.). If each of these two men is given an intelligent storeman-clerk, and steps are taken to define their respective responsibilities carefully, so as to avoid confusion or duplication, this system should work very well.

The question of the number, rank and duties of the other personnel of the staff of a small office is open to much debate. The Pay N.C.O. can and should deal with all questions and correspondence concerning pay and allowances and, except where the " Q " department is directly concerned, with questions of rations. It is open to question whether he should have any dealings with unit funds accounts. These are less tightly bound by regulations than public accounts, and thus demand closer supervision by an officer ; they should, therefore, be administered entirely by him, though pure routine work, such as the filing of receipts, can quite well be done by one of the clerks.

The registering and filing of letters is a department which seems to give more trouble than most. Frequently one hears of letters being wanted which cannot be produced at the critical moment. In order to avoid possible confusion, it is desirable that one individual should file and register *all* letters, but *all* the clerks must understand the system in use, so that any of them can at any moment take on the work. There always seems to be a tendency among soldier clerks to avoid registering letters if possible, the excuse being that they appear unimportant, or will never be required again. This is thoroughly unsound, as the most unlikely-looking letters are often suddenly wanted, possibly a year or two after they were originally received ; if they were not carefully registered when they came in, and the person who actually received them is not then in the office, they are not forthcoming, and trouble ensues. Against this, one does not want to litter up the files, particularly in a small office, with purely routine correspondence which will never be wanted. A useful compromise is to insist on every single letter or minute being registered in, however trivial it may appear at first sight, but to put those which are unlikely to be wanted again in a separate " rubbish " file or on a spike. At the end of each month, or at other suitable intervals, this " rubbish " file or spike can be carefully gone through by an officer, who can weed it out, putting those letters which must

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be kept (these will be fairly obvious after a few weeks) in the appropriate file, and destroying those which have no further significance. By a method like this, trace is kept of everything which comes into the office, and at the same time purely transitory matters are not allowed to clutter up the file cupboards, making important files difficult to find. On the subject of actual filing systems, everyone has his own ideas, and most systems have their merits. Two things, however, are essential :

(1) That some really efficient form of index, preferably alphabetical by subjects, shall be kept, by which a letter dealing with any subject can be traced, even though it were received in the office before the advent of any of the present members of the staff ; and

(2) That the system shall be one which permits of files being closed and put away as " dead " when no longer required, without all trace of them being lost, and which makes it impossible for subjects of files to become confused or the main subject side-tracked.

The normal division of work into the three branches, " G," " A " and " Q " will not apply in a small unit without modification. The branches exist, of course, but it is the " Q " branch which has to be kept separate while the " A " and " G " are combined. The " G " and " A " branches in a small office cannot really be separated; questions of personnel are inextricably mixed up with questions of training, and any attempt to keep the two branches in water-tight compartments will result either in unnecessary duplication or in some of the work falling between the two stools. The " Q " branch we have already discussed ; the other two branches are the main work of the ordinary clerks, of whom two should normally be sufficient. The division of work between the two must vary according to circumstances and to the individuals concerned, but assuming that one is a N.C.O. and the other a Sapper, the following arrangement will work quite well. The Chief Clerk registers and files all letters, assists in the administration of funds accounts, drafts replies to correspondence when he is able to do so ; the second clerk acts as typist for both the Pay N.C.O. and the Chief Clerk, amends official books, keeps up the men's documents and generally understudies the Chief Clerk. This last is most important, as he must be able to take over any or all of the Chief Clerk's duties at a moment's notice. According to the volume of work or correspondence which comes in, it may be desirable to have a third man in the office. He can run messages, clean the office, etc., in the ordinary way, but can also be of great use in carrying out thoroughly straightforward jobs such as copying returns, amending books, etc.

A system such as this is reasonably fool-proof. If the Pay N.C.O.

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goes sick, his assistant can carry on with that department; if the Chief Clerk becomes non-effective for any reason, the second clerk can replace him with the assistance of the orderly. In fact, the whole system can be progressive; as any member of the office staff drops out, the next man down the scale in that department replaces him, and the bottom place in that department is filled by a new man from outside. The only people who need ever come completely raw into the office are a new learner of pay duties or a new orderly; neither of these should seriously impair the efficiency of the office, and both should be able to pick up their duties very quickly.

The question of actual responsibility must be mentioned. The Pay N.C.O. and the C.Q.M.S. are directly responsible to the O.C. for their respective departments; the Chief Clerk is also responsible for the general work of the office. The second clerk is under the orders of both the Chief Clerk and the Pay N.C.O., and this is liable to lead to friction or confusion. One of these two, whichever is the senior, must be definitely put in charge of the general administration of the office, and it will rest with him to decide questions of precedence of work and other minor difficulties, if any. Correspondence should, in theory, be opened by an officer, but often this is not done; in this case the Senior N.C.O. in the office should open all letters and pass them to the individual whose job it is to deal with them. This duty may, in practice, very well be performed by the Chief Clerk, even if he is not the senior N.C.O. in the office, but whoever does it, it is important that it should always be the same man; this will ensure that there is never any question as to who received a particular letter, or as to how it came to be lost.

If some such system as that outlined above is adopted and is really running smoothly, as it should do without any trouble, the office work of the officer should be cut down to a minimum. He has under him three individuals, the Pay N.C.O., the C.Q.M.S., and the Chief Clerk, each of whom is an expert in his own department, and two of whom are replaceable at a moment's notice. The question of an understudy to replace the C.Q.M.S. is more difficult and cannot be discussed in detail here, beyond mentioning again the fact that all senior N.C.O.s should acquire a knowledge of C.Q.M.S.'s duties, and it will therefore pay to draft them all in turn into his department, so that they may learn something of that side of the work of a unit, without which they must inevitably lose some of their efficiency as R.E. N.C.O.s. There is practically nothing in this article which is not pure commonsense, but many of the points mentioned are apt to be overlooked owing, it is to be feared, to the normal officer's natural horror of being thought an office wallah. The office habit, than which there are few worse vices, is brought on and fostered far more by lack of attention to such details than by passing them over as things not worthy of the notice of a Sapper officer.

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THE L.G.O.C. OMNIBUS REPAIR WORKSHOP AT CHISWICK PARK.

By BT.-MAJOR G. MACLEOD ROSS, M.C., M.ENG., A.M.INST.C.E., R.E.

THE main object of this shop is to provide for the efficient annual overhaul which every one of the 4,000 buses of the L.G.O.C. fleet undergoes.

This overhaul may be divided into the repair and renewal of the bodywork, and the complete stripping of the chassis and its subsequent re-assembly.

The shop, designed to meet these two main requirements, is arranged in a series of 60 ft. wide aisles, divided across the short axis into two parts by the stores, one end being devoted to bodies—repair, manufacture of parts, and painting—the other end to chassis stripping and re-assembly.

The construction of the building is steel-frame, breeze walls and a pent roof covered with R.A.P.M. and roof lights, a concrete floor, 1½-ton Morris runways with pneumatic operated hoists where required, a combined heating and ventilating system, employing hot or cooled air as demanded.

An extensive system of cableways, sunk in the floor, provides for the movement of the bodies, whilst moving platforms and lines of rollers are a feature of the chassis side of the shop.

Generally speaking, the whole shop is designed for its normal job, and provides no extravagant plant for the unusual, and it is patent that the necessity for reducing standing charges to a minimum has guided the design of both shop and plant.

As a side line, provision is made for accidental damage, breakdown, and for non-standard vehicles, the last being dealt with at a separate bay.

The L.G.O.C. organization is such that at local garages, complete units only, *e.g.*, an engine or a transmission assembly, are replaced. Each garage carries a definite reserve of such spare unit assemblies, any faulty units are dispatched after replacement to Chiswick, whilst only damaged vehicles, or vehicles due for the annual overhaul, come whole to Chiswick.

On arrival, the vehicle for annual overhaul is first stripped of cushions, etc., and is then passed on to a large jack, where the body is lifted off and the chassis removed and run over under its own power

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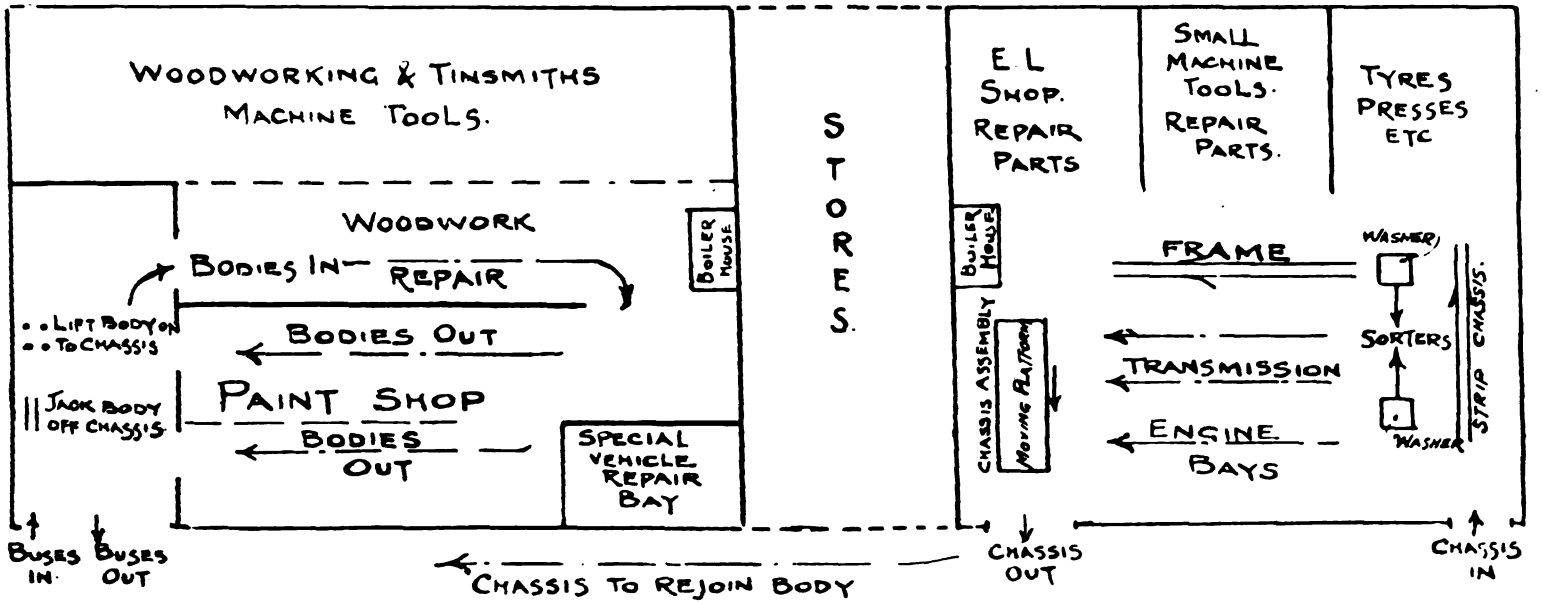
—SKETCH LAYOUT OF L.G.O.C. REPAIR SHOP— —AT CHISWICK PARK.—

—NOT TO SCALE.—



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to the chassis end of the shop. The body is then lowered on to a wheel-trolly, on which it remains until it is finally repaired and painted, and it is lifted back on to a new chassis at this same spot.

THE BODY.

The body is next stripped of advertisements and all broken panels, and woodwork.

It then enters the shop proper and is repaired as to woodwork and finally painted.

Interest attaches to the method of painting the red side panels. For these, after a coat of flatting has been put on by hand, a final coat is applied by pouring on paint out of a watering can with a wide, flat spout, surplus paint being collected for subsequent re-use in a trough running the length of the bus.

This method, which has been devised locally, is an interesting commentary on the prevailing vogue for spray painting, which is found to be less simply managed, requiring shielding of the glasswork, etc., and much more expensive as regards plant.

This final coat dries in one hour, and thereafter a single coat of varnish completes the work of the paint shop.

All notices are put on the bus body by means of water transfers, subsequently touched up with paint as necessary, and then varnished.

The trolly on which the body rests being attached to the capstan-driven cableway, it is then pulled along one space towards the point where a chassis will be met with.

THE CHASSIS.

The chassis is run over to the opposite end of the shop and placed on a line, where it is gradually stripped. All parts go into a washer, from which they are put on runways, off which they are picked by the inspectors of the various bays—engine, transmission, frame, etc.—to which they pertain and are sorted and coloured red, green, blue, depending on whether they are for scrap, immediate use, or repair.

These bays build up complete units once more from salved or new parts received from the stores, and these units all parallel on to a slow-moving platform, at right angles to the bay lines on which the chassis are re-assembled, the time for a chassis re-assembly being three hours.

From here the completed chassis is taken out under its own power and run in, being finally sent to the original entrance, where a new body is lifted on.

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Re-cushioning, notice-boarding, advertisements, licensing and police inspection complete the vehicle, which is then ready for delivery to a garage.

The chassis shop includes bays for the repair of electrical apparatus and of the reparable parts taken off the stripped chassis. Progress and co-ordination between the various sub-sections of the chassis and body sections is effected by attaching one man to each sub-section to note progress and effect liaison.

Each section is under an engineer, whose office is situated in the section shop.

Points of interest are :—

1. The sub-division into chassis and body sections.

These may be wide apart, but woodwork and painting are most efficiently placed under one roof, whilst all engine work is also under one roof.

Ablution places and latrines are also inside the shop, the former unscreened.

2. The washing of the chassis parts ensures easy detection of faults, and saving in handling, storage, and assembly time.

3. The modest efficiency of the plant employed is noticeable. The Morris runways are preferable to travelling gantry cranes, since they are lighter, cheaper, handier, and provide power where it is wanted.

4. The general layout shows once again how essential it is for the designer of the shop to know exactly the operations proposed by the users of the shop, and, more essential still, the need for the users to have a definite plan on which to organize their work, and finally, having decided on a plan, to adhere to it.

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SIR THEO D'O LITE AND THE DRAGON.

By CAPTAIN J. C. T. WILLIS, R.E.

AT a certain time and in a certain town there was an Error. And the Error was a Dragon. And the citizens in the town lived in fear of him. And one day there journeyed to the town a Knight of the name of Sir Theo d'O Lite, and he set up his tent by a table made of logs, and out of the logs, which were arranged in columns, he now and then took a lozenge. And the lozenges were black and he hated them. But he had a high courage and an x 20 resolving power, for he was young and swung easily about his broad base as he did his work, thinking always of the fate of his poor father who perished at Chatham after suffering acutely from a broken diaphragm (Young Officers under instruction please accept this, the only intimation); he had but lately left his maker and was newly graduated. And he carried in his hands a volume of short reeds (seven figures).

And there came to Sir Knight as he sat by his logs outside the city, making quiet observations of men and things, a deputation of leading citizens. And the head of the deputation was Sir Veyor of the Borough. And they told the Knight of a Dragon which had long terrorized the town and could in no wise be eliminated. For the Dragon represented much work that had been done of yore. And his methods were shaky. And his results even more so. And they besought the Knight to do battle with the Dragon. Now the Knight was a level-headed man and, though he always carried alcohol on his person, it was not upon the alcohol but upon the bubble in it that he relied for his best results. But there were those, his detractors, who called Sir Knight "double-faced." For, said they, he is ever on face right, or face left, and only when he is at last laid in his little wooden box will he be cured of this failing.

And Sir Theo listened to the tale of woe told him by the citizens, and his hairs crossed and his diaphragm rose at the thought of it. And when the citizens had made an end of speaking he cried, "To-morrow I will set myself up upon a hill without the city, upon the hill where is a house called the 'Sun' (off-licence), and there will I take solar observations, and being a geologist will study the pintz and quartz which are within, until such time as ye bring me the Dragon for to do battle." And it was so. And, behold, the following morning before the "Sun" (or its proprietor) had arisen, the Dragon came forth to battle.

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Now the Dragon was a fearsome monster and covered with scales. The scales were of three kinds—large scale, of which he had 10,000; medium scale, of which he had 25,000; and small scale, of which he had 250,000. He had also an index. And his eyes shone like cadastrals, or like those of an observer when the three angles of his triangle add up to 180° 00′ 00″. His tongue was forked into two points and the points thereof were called "True North" and "Magnetic North." And his tongue was in his cheek, like that of an observer when the three angles of his triangle do *not* add up to 180°, or anything like it. But he was no longer young and increasing years had brought a marked convergency to a figure that was no longer capable of precise adjustment, and like plane-table legs, or the English yard, he possessed three feet. And his movements were slow and deliberate, as of an employee whose pension is even now in sight, and before each step he took a forward bearing and a reverse bearing and checked himself as against gross error.

And the Knight arrayed himself in all his panoply, his sun guard and his optical centring; and, illumined by an inner light (12 guineas extra), he wiped away all traces of collimation from his eye and turned upon his base.

Thus began the battle; the Knight and the Dragon doing battle for the peace of mind of the citizens of the town. And the Knight turned himself face right and face left, but never could close. And the Dragon, traversing slowly, breathed fire upon the Knight; but the Knight stood rooted to the ground, for none of the famous family of Theo d'O Lite can shift their legs and still remain level-headed. And the encounter waxed sore. And the heat of the Dragon's breath caused the very bubbles on the Knight to contract, and turned what had been a mean elevation into a marked depression. And Sir Theo's eyes grew misty.

Thus and thus did they fight all day and neither could gain the advantage. Could the Knight but close, the day was his. But as even wore on he grew stiff, his refraction was giving him trouble and he felt machine-divided. The Dragon's tail also hung limp, like a swinging traverse, and his scales expanded from the heat and were inaccurate. So they appealed against the light and the citizens allowed the appeal. For they, too, were thirsty. And the fight was to be rejoined at 10 a.m. on the following day.

And the fight that day was celebrated in song and story, but no historian durst tell the truth and even if he had Sir Theo would have censored it. For Sir Theo had gone into the fight that day with all his armour on but, alas, had forgotten to tighten his base plate. And so he could not close.

And that even Sir Knight bethought him and minded him of another house upon the hill, to wit "The Magnet" (to be consumed on the premises only). And thither he stole that night and took

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with him his lance. And there he stayed and besought aid of the proprietor, who, in great courtesy, agreed, and polarized his lance for him. And the Knight gave the proprietor some quartz. And the Knight left with a slightly tangential screw, and passed through the sleeping city to the training quarters of the Dragon. He passed the silent cottages, past the Dragon's manager's house, where the manager was expressing " The utmost confidence in the result of the morrow " to the representatives of the *Morning Press*, past the room where a hired scribe was busy writing two articles for the subsequent signature of the Dragon, the one entitled " How I Won " and the other " How I Lost," past an ironware shop where Sir Knight was delayed by the adventitious collection on his polarized lance of four saucepans, a kettle and one teapot, this latter reputed to be silver but of a hall-mark which had long defied detection. These he removed with difficulty with the exception of the teapot, which, like many others before him, he retained for a closer inspection. So came he at last to the place where the Dragon lay sleeping. There wrought he with cunning, for with his lance he stroked the Dragon gently from nose to tail and for a long while, and lo, the sleeping Dragon also was polarized. And the Dragon purred in his sleep and dreamt that he had successfully answered an advertisement on " How to Acquire Magnetic Personality."

And the following morning what shall one say of the fight. For the Dragon, heavily polarized, and pointing always to the north, could turn neither to the east nor yet to the west. In fact, as the Austin Seven is to the tram, even so was the Knight to the north-pointing Dragon. And the Knight thrust his lance between the Dragon's scales where there was no overlap. And with one last grid reference the Dragon fell. And the Knight bound him and dragged him captive to his domain in the " Sun." And the citizens gathered round the " Sun " and waited without. Without the house and without refreshment.

And they waited long. And as they waited they heard sounds of laughter and revelry and the clink of glasses, and peering through the curtains they saw the Knight and the Dragon, and, lo, they were fraternizing, for they were drinking fudge (by the method of least squares). And lo, their errors were compounded and they meaned their results and interpolated to second differences. And, behold, there was no Error.

And in the even the citizens stole away and from the place in the " Sun " where the Knight and the Dragon stayed came softly o'er the wind the words :—

" Should cos and tangent be forgot
In the days of auld log sine."

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Wing-Commander Bernard Edward Smythies, D.F.C., R.A.F.

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MEMOIRS.

WING-COMMANDER BERNARD EDWARD SMYTHIES, D.F.C., R.A.F.

WING-COMMANDER BERNARD EDWARD SMYTHIES was killed as the result of an aeroplane accident on the 17th June, 1930, and the Air Force thereby lost a most experienced and valuable officer, whose work was appreciated by a wide circle not only in the Air Force but in the Navy, Army and Civil Service. For several recent years he had worked in the Directorate of Operations and Intelligence at the Air Ministry, and had represented it on many inter-departmental committees and on Sub-Committees of the Committee of Imperial Defence.

The son of Mr. A. Smythies, of Dolton, North Devon, he was born on December 9th, 1886. Educated at Cheltenham, he joined the Royal Military Academy in 1903, and was commissioned in the Royal Engineers in August, 1905. At the outbreak of War in 1914 he was acting as an Instructor in the School of Electric Lighting. Promoted Captain, R.E., in November, 1914, he was shortly afterwards attached to the Royal Flying Corps, and after a course of training at the Central Flying School, he was posted to the Royal Flying Corps as a Flying Officer in January, 1915.

His previous technical training and his experience in electrical matters led to his being posted to No. 9 Squadron, which was then responsible for the whole of the wireless activities of the Royal Flying Corps in France—flights of No. 9 Squadron being attached to other squadrons in the field for wireless duties. At that time few officers had any first-hand experience of W.T. work, whilst even operators were borrowed mainly from the Royal Engineers.

It is not surprising, therefore, that Smythies, with his wide technical knowledge, and an inherent scientific bent, was retained for a considerable time as a technical officer. At first he regarded his position with impatience, for, as he then urged, he had joined the R.F.C. to fly. Later, as he became immersed in what was obviously an increasingly important branch of air work, and as his technical duties permitted a certain amount of flying, he became more reconciled to his separation from active flying with a squadron. In April, 1915, the work of No. 9 Squadron was taken over by No. 1 Aircraft Park, and Smythies perforce went with the work.

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By February, 1916, however, his importunities resulted in his being posted to full flying duties. For six months he was engaged on flying-training and night flying in England, before being given command of No. 64 Squadron, on formation. In October, 1917, he led this squadron over to France. Equipped with De Havilland 5 aircraft, the unit was employed on the 3rd Army front as a single-seater scout squadron, and was early engaged in the Cambrai battle of November, 1917. For the remainder of the war, Smythies commanded No. 64 Squadron, and during this period he was witness of the disastrous retreat of the 5th Army, on which front his squadron was thrown in. The squadron was also on the Arras and Ypres fronts during battle periods, and was active in the victorious advance of late 1918.

Writing some years later of the 5th Army retreat, he said :—

> " The sight of our retreat is unforgettable : miles of road packed four abreast with vehicles, tired troops in the open regardless of cover—all affording a wonderful target for enemy low-flying aeroplanes. History will relate why there were so few ; it was probably due to the concentration of our fighter patrols, to whom the low-flyer five miles our side of the lines was an easy and coveted prize."

The disasters of the March retreat left the morale of his squadron unmoved, however. Like most squadrons and especially fighter squadrons, the morale and efficiency of the unit rose and declined under influences largely independent of conditions operating on the ground with the Army. Generally the movement was in what he himself described as a cyclic evolution. He regarded his squadron as at the highest point of morale and efficiency in May, 1918, and he was not afraid to confess that by September of that year, largely owing to heavy casualties and replacements, the squadron was reduced to a collection of amateurs. Before the Armistice, however, the old *élan* had returned, and the squadron was well up the ladder again.

For his gallant services and for his tireless labours with No. 64 Squadron, he was awarded the Distinguished Flying Cross. With characteristic modesty, commenting on his work in the air in March, 1918, he wrote :—

> " This was my first experience of air fighting on a big scale : I was but an indifferent pilot and a thoroughly bad shot ; never, otherwise, could I have believed the difficulty of obtaining a vital hit on a fast-moving target. My flight commanders were admirable, one particularly being gifted with marvellous eyesight."

That was typical of Smythies. Steady and dependable, he shared all risks and set a quiet example. Hating exaggeration and intolerant of inaccuracies, he subjected the reports of his more imaginative

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pilots to stern scrutiny, and cloaked the exploits of his own squadron in modest statements of fact.

After the war he served for two years in England, where once more his technical abilities led to his employment as an instructor in astronomy and mathematics at the School of Air Navigation. He then served a short period in India on Air Staff duties, and returned for the first Staff College course at Andover, graduating in April, 1923. He then once more commanded a fighter squadron—No. 41, before being appointed to the Plans Branch of the Department of the Chief of the Air Staff at the Air Ministry.

It was perhaps in this appointment that his abilities found their fullest scope. Gifted with a well-balanced and well-furnished mind, he proved himself an admirable Staff officer. The period of his service in the Air Ministry coincided with that marked development of inter-service consideration of defence problems, which was the natural consequence of the establishment of the Chiefs of Staff sub-committee of the Committee of Imperial Defence. Smythies took a considerable share in the preparation of material for the deliberations of the Chiefs of Staff Committee, and in that work, as in all other which came within his sphere as a Staff Officer, he showed himself to be accurate in knowledge and shrewd in judgment.

To plan a memorandum or to labour on an essay was a joy to him. He wrote in convincing and attractive style, and on three occasions he was a prizewinner in the annual "R. M. Groves Memorial Essay" competition.

After his tour of duty at the Air Ministry he commanded No. 99 Night Bombing Squadron. He believed that example in the air and the sharing of risks with his own pilots were essentials to a good commander, and he held that no full appreciation of the varying problems of air warfare could be acquired except by a certain amount of actual flying. Largely for these reasons he commanded a squadron whose efficiency was on a high level.

When he left this squadron in August, 1929, to take up the command of North Weald Station, he still continued to practise this precept of maintaining flying efficiency, although his appointment was essentially an administrative one. He was killed as he was taking off from the ground, due to the aircraft striking an obstruction.

If he had left any message he might well have chosen the words with which he closed an account of his war experiences which he once wrote :—

> "For us who still serve, the task lies ready at hand : only by studying the tradition and experience of the past can we equip ourselves to take advantage of the future, handing on to our successors that fine spirit which animated those who are no more."

N.H.B.

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LIEUT.-COLONEL SIR JOHN NORTON-GRIFFITHS, BART., K.C.B., D.S.O.

EARLY in 1915, after mining on the Front in France had been in progress for a month or so, the W.O. informed G.H.Q. France that an officer named Major John Norton-Griffiths, of 2nd King Edward's Horse, who, by profession, was an engineer and contractor for the construction of tunnels in clay, had given certain information based on the experience gained in his work which appeared to have value with regard to our mining operations in France ; and it was suggested that this officer should be allowed to come to G.H.Q. to place his information at the disposal of the Engineer-in-Chief.

Accordingly on Saturday, the 13th February, 1915, Major John Norton-Griffiths walked into the Engineer-in-Chief's office at St. Omer.

I was assistant to the Engineer-in-Chief at the time, and I think both he and I were relieved to find that the man in question really possessed practical knowledge of his subject, and was one to whom the word " impossible " was unknown, and whose forceful character and enthusiasm swept away all opposition to his proposals, and at the same time was a most interesting and amusing companion.

What Norton-Griffiths had come to France for was to press for the application of a system of tunnelling in clay called " clay kicking." He stated that as a contractor he had had long experience of this system, he knew that it was rapid and absolutely silent, and was quite sure that, if it was adopted in our mining, we would soon recover the initiative in that form of warfare which we had lost for the present.

He said that he was at that moment just completing a contract for making tunnels by this process for a drainage scheme at Liverpool, and was prepared to place the whole of his tunnelling personnel at the E.-in-C.'s disposal. He had brought with him one of his assistant engineers and a foreman to assist him in making an inspection of the nature of clay on our mining front.

The E.-in-C. and myself had both occupied the appointment of C.I.F. at the S.M.E., but neither of us had ever heard of " clay kicking," and were perhaps inclined to be sceptical, but after a long discussion it was decided that I should take Norton-Griffiths, his engineer and foreman (Lieut. Leeming and Serjt. Miles), down to the Givenchy front the next day. Starting at 8 a.m., we had to call at the headquarters of each formation to get a pass forward to the next. We went through five of these, at each of which Norton-Griffiths stated his case and gave an ocular demonstration of how

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"clay kicking" was done, on the office floor,* much to the astonishment of his audience.

On arrival at Givenchy, the mine in the "orchard" was inspected and Norton-Griffiths was satisfied that the clay was suitable; his foreman was enthusiastic and said that the sight of that clay "made his mouth water." This satisfactory report was duly repeated at each headquarters as we returned to G.H.Q., where we arrived at 11.30 p.m.

The next day was spent in conference with the E.-in-C., thrashing out the details of the organization, personnel, transport and pay of the special companies which were essential if this system of mining was to be introduced.

Norton-Griffiths having convinced the E.-in-C. that they were necessary, the latter reported the fact to the General Staff, and a telegram was sent to the W.O. asking for authority to form these units; the necessary authority was received next day.

There was some discussion as to the title of the companies. Norton-Griffiths wanted them called "Moles," but the War Office traditions had to be followed, and they were christened Tunnelling Companies, but many of the companies kept the "mole" as a company sign, and on their Christmas cards.

The next day was Tuesday, and Norton-Griffiths returned to England to collect the original draft of R.E. for the Tunnelling Companies. The way he did this is worth while recording, for it gives a very clear idea of his method of working, and his extraordinary energy in getting things done: On Wednesday, he was in Liverpool closing down his contract, and selecting those men of his employees who would be suitable for the work in France. On Thursday, he appeared at Chatham with 18 men, who were then and there attested, clothed, and made into Royal Engineers. On Friday night, he returned to France with them, arriving at Bethune on Saturday, and saw them start work underground at Givenchy on Monday. I always think of this move as the quickest *intentional* move of the war.

Norton-Griffiths' own movements during the formation of the first five companies were meteoric. He was provided with a mandate by the A.G., G.H.Q. which enabled him to visit all units containing officers and men who had mining experience, and to select from them personnel for the Tunnelling Companies. He did this with his unfailing energy and enthusiasm, combined with his wonderful persuasive powers and irresistible good humour. He used to claim that his experience in lobbying in the House of Commons was of untold value

* Clay kicking is a method of excavating a tunnel in clay only. The clay kicker lies on his back on a wooden frame called "the cross," feet foremost, and works his way forward by means of a narrow-bladed spade called the grafting tool. He passes the spoil over his shoulder to his mate behind.

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to him when he was up against a Commanding Officer who very naturally objected to being robbed of his best men in order that Norton-Griffiths might form a Tunnelling Company; but Norton-Griffiths always got his way, and the C.O.'s feelings were somewhat salved by the appearance of a Rolls Royce car at his headquarters with sundry wooden cases for disposal! Norton-Griffiths was here, there, and everywhere, holding parades, selecting officers and men, dashing across to England to collect certain men, stores or instruments, and conducting them personally from any of the channel ports at any hour day or night, to their final destination, occasionally finding time to look in at the E.-in-C. to report progress.

When the companies got down to their work, Norton-Griffiths was the E.-in-C.'s recognized liaison officer for mining work, and it was through his inspection reports that the E.-in-C. was kept up-to-date with regard to the mining situation. These reports recorded all his own doings and those of everyone else he met, and were written exactly as he felt at the time of writing. Some of the contents were highly secret, most of them were interesting, and all of them entertaining. We called these notes "Punch," and the issue of each new number was eagerly awaited by the E.in-C.'s Staff. Norton-Griffiths was quite indefatigable, and after the hardest day was always ready to spin a yarn about his early life, life in the House of Commons, or electioneering adventures as "Empire Jack," because he always had a map of the Empire and the Union Jack on his platform, and by degrees we began to understand the nature of the man who had come among us, and who told us, as he surveyed his work of creating the Tunnelling Companies, that no regular officer could have done it. I, for one, am perfectly certain he was right.

His powers of judging a man were remarkable, as I know well from my association with the Tunnelling Companies and their officers later on. He rarely, if ever, made a mistake in a selection for a commission. I asked him one day how he did it, and he said with a twinkle, "I look a man straight in the eye," and I can vouch for it that the ordeal of being looked straight in the eye by Norton-Griffiths was no mean one.

He was a man of action if ever there was one; and we in the E.-in-C.'s office were not the only people impressed by that quality. Some years after the war, I was going down Whitehall on the top of a bus watching the road being broken up by the pneumatic drills, which were just coming into general use for that purpose. The man next to me suddenly said, "Well, if Empire Jack had had his way they'd have been used for this long ago." I said, "What do you know about Empire Jack?" and he said that he had worked for him for some years, and added, "but he's a terrible man." "Terrible man?" I said, "why terrible?" He said, "Well, I was down at one of his

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meetings in Wandsworth, and he was making a speech, and there was a fellow there interrupting and wouldn't stop, so Empire Jack just got down from the platform, walked to the man, knocked him out, and then came back and went on with his speech. Oh, he's a terrible man."

Anyone who was in contact with him could not help being impressed by his intense enthusiasm; his ability was undeniable, the only thing we never got quite used to was his total disregard for the proper military procedure.

Another characteristic of the man was his large-mindedness. His schemes were always on the grand scale. His nickname in the House of Commons, "Empire Jack," is significant, and he often spoke of his connection with contracts in Canada and Australia, which involved millions of capital. It was, therefore, almost natural to expect that he would foreshadow a mining scheme on a large scale, and so it happened. Early in August, 1915, he produced a very roughly worked out plan for extensive deep-level mining on the Messines front. This scheme was altogether too sketchy to be seriously considered, so he and I got down to details, and the result was the framework on which the mines used at the Battle of Messines were planned, and fired nearly two years later.

When mining was made a separate branch of the E.-in-C.'s office, and an Inspector of Mines at G.H.Q. was appointed, Norton-Griffiths' position as liaison officer was redundant; so, having collected the Staff for the new Inspector of Mines, and seen the office fairly started, he said he must return to England to resume his parliamentary duties; this was in April, 1916, but I think he was already seeking some new excitement, and after a very short stay in England we next heard of him wrecking the oil wells in Rumania.

His restless spirit has now "gone forward," but his work while he was attached to the Royal Engineers may be traced in those pages of history, which describe the achievements of the Tunnelling Companies. Without him, the companies as we knew them had never been formed, and their crowning success, the "Mines of Messines," had never been realized. *Lest we forget.*

R.N.H.

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SIXTY YEARS AGO.

THE
ROYAL ENGINEER JOURNAL.
FOR PRIVATE CIRCULATION ONLY.

AUGUST 1ST, 1870.

C TROOP.

The Corps having been augmented by C, or the Telegraph Troop, it is considered that it may not be uninteresting to give a brief sketch of this new equipment.

The Telegraph Troop consists of 24 carriages, viz.: 4 office waggons, 12 wire waggons, 3 general service waggons, 1 pontoon waggon, 1 forge, and 3 artificers' waggons.

The whole of these carriages have been constructed with springs, which is a novelty in military carriages, and are lighter in every case than those generally used for military purposes.

The wheels are the 3° class wheel, with madras nave and a 3″ tire.

The Office Waggons contain the instruments, writing materials, &c., and are constructed with a roof and sides of Clarkson's patent material.

The Pontoon Waggon, which carries a bay of super-structure 15′ and a pontoon boat, of the new pattern for putting the cable across a river; the bay is for crossing a small opening.

The Wire Waggon carries three miles of insulated wire; this wire is composed of 3 No. 20 B W G copper wires, tinned over; diameter of the conductor is .064″ insulated to a diameter of .206 with vulcanized India Rubber, and protected by a layer of strong canvass, covered by two thicknesses of tape primed with India Rubber, the diameter of the whole being .3 of an inch.

Each Wire Waggon has six drums, these drums revolve on pivots fixed on the sheers of the carriage.

The two rear drums are rolled up by a band worked from the wheel of the carriage. Each drum to be reeled up is transferred to the rear of the carriage and worked by the band. The wire is laid out along the road; the place selected is the fence or side of the road; when a road

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has to be crossed, telescopic iron poles are put up which raise the wire sufficiently high to allow carriages to pass underneath.

The Cable is not easily cut by carts passing over it; indeed, a battery of artillery has gone over it very often without doing harm.

The junctions of the wires are made with Mathieson's ebonite jointers. This Troop comprehends twenty signallers. These men are equipped with telescopes and signal flags; their use is to prolong the line of communication and obtain the information which the regimental signallers may furnish, transmit it to the Office Waggon, from whence it is telegraphed to Head Quarters. The whole troop composes a unit of Field Telegraph, and is the proportion for a Corps d' Armee as laid down.—*W. O. Circular*, 26th Feb., 1866.

RETIREMENT SCHEME.

The question of retirement for the Royal Engineers is one of national importance, inasmuch as the efficiency of the Army depends on the efficiency of its different portions. It is a question which sooner or later must be viewed in connection with the question, how a Reserve Force shall be officered?

Without dwelling on this subject in its most important, a national bearing, we propose to offer to the officers of the Corps a precis of the proposals of the Committee of which Capt. Vivian was President, and which have been submitted to the Secretary of State. This Committee states, that the average promotion in the Infantry, purchasing and non-purchasing, at the present moment, is as follows:

Lt.-Colonel	23.3 years
Major	17.9 ,,
Captain	8.8 ,,
Lieutenant	2.8 ,,

But assuming the above to be a correct statement, the Committee for some reason not stated assume the standard periods in the Artillery and Engineers to be as follows:

Major-General	40 years
Colonel	34 ,,
Lt.-Col. with Major's pay	25 ,,
Captain	18 ,,
Second Captain	12 ,,

In the case of the Royal Engineers, the Committee propose to add one year to the standard times, thus any officer may, by looking at the following table, see how he will stand with reference to Infantry officers:

	Infantry	Eng.	
Lt.-Colonel	23.3	26	with Major's pay
Major	17.9	18	1st Captain
Captain	8.8	13	2nd Captain

It is well known that there are but three ranks of Officers in the Army: *Company Officers, Field Officers, and General Officers;* thus to become a Field Officer, the Engineer must serve 8.3 years more than the Infantry officer.

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There will, therefore, as the Committee justly observes, be no danger of his ever superseding the latter.

Lord Raglan's minute of the 12th July, 1854, may here be quoted.—"The situation of the Subaltern officer of Engineers is undoubtedly peculiar. He has various duties to perform, always important, very frequently onerous, as well as involving responsibility to an extent unknown to any officer of his relative rank in any other branch of the service." This is true of all ranks in the Engineers—under the proposed regulations the state of the Corps will be worse than when Lord Raglan wrote.

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

THE REAL WAR, 1914–1918.

By B. H. LIDDELL HART.

(Faber & Faber, Ltd., London, 1930.) Price 12s. 6d.

A short history of the World War in 500 pages, with a very useful Bibliography, a fairly good Index, and some maps and sketches. The author was an undergraduate at Cambridge when the war broke out, obtained a temporary commission, was wounded on the Somme, and was unable to take any further part in the operations. His first-hand knowledge of many of the subjects he discusses is, therefore, limited, but being a clever man, he has managed to acquire and assimilate a vast amount of information from books, documents and "gup." He has used this material well, sometimes ruthlessly, and the result is a readable book in which the author's comments and deductions are well worth considering, whether one agrees with them or not.

In his preface, the author explains the title, "The Real War." He warns the reader that he is not going to gloss over disturbing facts so that individual reputations may be preserved at the price of another holocaust of lives, and that he cannot regard the repute of a few embodied handfuls of dust as worth more than the fate of a nation or a generation. He considers that the history of the war, as so far presented to the public, gives only one side of the story, that of the Cabinets and Military Headquarters: and that the other side—that of those who fought in the ranks and those who lost their best—has not received sufficient recognition. Therefore he uses the word "real" as describing what actually happened, not what has appeared in print. He further claims that the time has come when a "real" history of the war is possible, since all that can be known is known. The private diaries of Earl Haig and others have yet to see the light, so possibly he is a little "previous."

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It is a feather in the cap of the official historian that the author holds him in sincere respect, and often quotes him.

Although the author states in his opening lines that the subject is so immense that it cannot be included in the scope or the space of a short history of the war, he gives us in his first chapter a very able summary of the "Origins of the War," and he follows this up with an equally clear dissertation on the "Opposing Forces and Plans." Both chapters will be useful to the military student.

In describing the various phases of the war, the author gives us his own conclusions in each case, and it is these that make the book so interesting. Referring to the British share in the French plan of campaign, he writes:—"When the General Staffs of the two countries "conducted their informal negotiations between 1905 and 1914, they "were paving the way for a reversal of England's centuries-old policy— "the exploitation of mobility given by Sea-Power—for a war effort "such as no Englishman had ever conceived. Lord Kitchener had a "remarkably accurate intuition of the German plan, and tried to avert "the danger threatening her as an appendix to the French left wing, by "advocating that the B.E.F. should concentrate near Amiens, where it "would be less exposed. But the vehement support given by the "Commander, Sir John French, and his Staff to the French plan, induced "Kitchener to give way." Later he "lamented his consent as a "mistaken weakness."

At some future date Captain Liddell Hart ought to give us a series of studies on various phases of the war. Here we have two interesting problems. What would have happened if the B.E.F. had concentrated at Amiens? And—was the landing of the B.E.F. on the Belgian coast a sound and practicable plan? The intuition of Lord Roberts, and of Mr. Winston Churchill, evidently pointed to the latter course. Lord Fisher had the same idea, the utilization of our sea-power, always in his mind.

The failure of the Germans to capture the Channel Ports in the initial stage of the war after the retreat of the Allied left wing was, he says, an incredible blunder, and cost them tens of thousands of lives when they attempted to repair the omission after the so-called "race to the sea"—a term which the author describes as inaccurate.

He attributes the failure of the Allies to make the victory of the Marne complete partly to the comparative weakness of Manoury's flank attack, but still more to the failure of the British and Fifth French Armies to drive rapidly through the gap which lay open before them. "Their direction of advance"—he writes—was "across a region intersected "by rivers, and this handicap was intensified by a want of impulsion "on the part of their chiefs, each politely looking to his neighbour, and, "timorously, to his own flanks." Critical though he is of the Allied leadership, he does not spare Moltke and the German Command for their conduct of the operations up to the battle.

And so, in discussing each phase of the campaign in France or other theatres, Captain Liddell Hart is able to intrigue us by some outspoken criticism which arrests our attention, for he crystallizes in print what we have ourselves always felt might have been the case. For instance, in

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his summary of the Battle of the Somme, he writes :—" The folly of the " last phase from Sept. 25th onwards was that, having won at last the " crest of the ridge, and its commanding observation, the advantage " was thrown away by fighting a way down into the valley beyond. " Thereby the troops were doomed to spend the winter in flooded " trenches." Would not his criticism apply equally well to the fruitless Battle of the Ancre, in November, when the whole area was a sea of mud?

And still more would it not apply to the Battle of Paschendaele, where there is no doubt now that operations should have ceased on Sept. 24th, 1917, instead of being uselessly prolonged at such enormous cost into November? The tendency of the military commanders always to take the offensive without counting the cost is discussed by Captain Liddell Hart, curiously enough, in his naval chapter on the Battle of Jutland, or, as he calls it, the Battle of Blind Man's Buff. " A fundamental difference " —he writes—" between the higher naval command and military leader- " ship in the World War was that the Admirals would not intentionally " give battle unless reasonably sure of an initial advantage, whereas the " Generals were usually ready to take the offensive whatever the dis- " advantages. In this attitude the Admirals were true to their art, " the Generals were not. The sole reason for employing men who have " made war their profession is the presumption that by training they " have acquired a mastery of their art. Anyone with sufficient authority " or inspiration can lead or push men to battle, especially if he is fur- " nished with technically-trained assistants who can help him to regulate " the marshalling of the forces in movement and fire. For this shep- " herding of sheep to the slaughter, perhaps artful but essentially inart- " istic, a practised demagogue would have a definite superiority over the " tongue-tied professional warrior. But the custom of employing " a professional is based on the idea that through art he will be able to " obtain more profit at less cost. Only one consideration should over- " ride a commander's fidelity to the fundamental truths which govern " his art, and that is national expediency. . . . In the World War the " Generals were so full of lust for battle that they voluntarily sacrificed " art, and repeatedly sought battle at a disadvantage and against the " wishes of a Government reluctantly dragged in their wake. The " Admirals, in contrast, were so faithful to their art that they sometimes " ignored or evaded the express wish of the Government for battle, even " without an assured advantage. If their sense of reality was refreshing, " it tended to throw a heavier burden of expense on the armies, though " it is fair to point out that this might not have occurred if the Generals " had not been so extravagantly eager to shoulder it."

The criticism is clever. But it may be fairly urged that Captain Liddell Hart does not take into consideration the difficulties caused by Allied leadership, and that it is not only national expediency in the interest of his own nation that influences the conduct of its Commander.

The fact that " Jellicoe was the only man who could lose the war in an afternoon " is not ignored by the author. His conclusion is—" But, " if discounting all criticism, we admit that Jellicoe's handling of the " battle fleet was the flawless masterpiece that numerous naval admirers

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" argue, the admission only strengthens the belief that the worst fault " of the Jutland Battle was that it was ever fought." The reviewer takes leave to disagree, for it taught our Navy lessons which it and the nation will never regret.

Space does not permit reference to others of the author's many outspoken comments, but one cannot conclude without referring to his interesting chapter on the " Battle of a Nightmare—The Meuse—Argonne," and the " Epilogue " which completes the volume.

H.B-W.

RECORD OF THE ROYAL GEOGRAPHICAL SOCIETY.

By Dr. H. R. Mill.

The Royal Geographical Society celebrated, in October of this year, the completion of the first hundred years of its existence by the formal opening of its new Lecture Hall and other additions to its building, and by the publication of the Record which is the subject of this review. The account was written by Dr. Mill, but was subjected to the invaluable supervision and criticism of Mr. Douglas Freshfield, a distinguished ex-President and one of the oldest Fellows of the Society. Two chapters are due to Mr. Hinks, the Secretary.

Dr. Mill has produced a most readable book. The mere collection of the facts, and selection of what could be included and what must be omitted, must obviously have involved very heavy work. But the book is no mere chronological record of events. It is written in most human fashion, and is enlivened by occasional anecdotes and sidelights on character and idiosyncrasies which make it delightful reading. Further, the plan of the book being a division into periods, the events in which are described in order, each period is prefaced, in order to provide a background for the account of the work of the Society, by attractive pen-pictures of the conditions of life in the country at the time. These, necessarily brief, but vivid and full of humour, are a most pleasing feature of the book.

The Record opens with a short account of geographical history and happenings prior to the formation of the Society, and then shows how, from the African Association and the Raleigh Travellers' Club, by a succession of steps which are now for the first time set out in orderly sequence, the Royal Geographical Society of London, as it was at first called, came into being in July, 1830. Few things in this book are more interesting than the record of the ten " Founders " of the Society. It is not surprising that it should have been an infant of vigorous growth with sponsors of such remarkable character and personality as these. Barrow, a man of humble origin but great ability, who became one of the greatest all-round geographers in the country; Baily, most intrepid of travellers, a founder of the Royal Astronomical Society, and one who " completed the whole round of Geography from adventurous travel to mathematical computation "; Britton, who started as a pot-boy and

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ended as a leading antiquarian; Colby, a lifelong member of the Ordnance Survey, its chief organizer, and for over 30 years its Director; Murchison, soldier, country squire, artist, geologist, and later one of the greatest Presidents; and others whom there is not space to mention. It is perhaps surprising that such men should have worked together as an orderly team; but this was due, Dr. Mill says, "to the masterful efficiency of Barrow, to whom, more than to any other man, the strength of the foundations of the Royal Geographical Society was due."

The Society thus started happily, and, but for a period of stagnation in its second decade, flourished and increased in membership. The chief interest of the Society, at its start and for many years after, was exploration and discovery; and this was right at a time when the world still contained enormous tracts of undiscovered and unmapped country. It was not for some considerable time that the Council could be induced to recognize that there were other geographical activities worthy of consideration, such as education and research, and then mainly by the efforts of Galton and Freshfield. But at first it was exploration only, and the Society took, by general acknowledgment, the foremost part in undertaking, encouraging, or rewarding geographical discovery in all parts of the world, and by travellers of every nationality. Those were halcyon days when the Society's meetings were addressed by men whose names are now household words, recounting recent and romantic discoveries in the unknown regions of the world.

In the history of the Society certain names stand out, as having influenced its destinies or moulded its character, and among the chief of these may be mentioned Murchison and Markham, to whose periods of ascendancy three chapters are devoted. Roderick Murchison, having been a founder, was President four times and for sixteen years in all, and for some twenty years (1851–1870) was the ruling spirit of the Society. Clements Markham was a Fellow for fifty years, an Honorary Secretary for twenty-five, and President for twelve (1893–1905). The Society owes much also to its Secretaries, both honorary and paid, and Chapter VI deals mainly with these. Among the former, in addition to Markham already mentioned, the names of Freshfield and Leonard Darwin stand out, while of the latter Bates and Scott Keltie are conspicuous, both on account of the length of time they held office and of the influence they had on the Society.

The Society in its first forty years occupied various quarters, but in 1870 moved to 1, Savile Row, where it remained until 1913. To a younger generation this address is probably better known as the house of a famous Army tailor; but for over forty years it was, in Dr. Mill's words, "the Mecca of all true geographers, the home port of every traveller." To quote further, "The earlier homes of the Society have been swallowed up in the transformation of London, but even when 1, Savile Row also passes away the spirit of Geography must surely continue to haunt that corner." Great men resorted to that house; great events took place quietly there; and surely none more remarkable in its poignant tragedy than the return of Livingstone. Murchison had longed to welcome Livingstone in the new home of the Society but before

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that could happen both men had died. The body of the great explorer was brought to Savile Row. " Now the sunset light with gentle irony shone through the western windows upon the silent meeting of the returned traveller, a mere vestige of humanity, and the waiting President, a marble bust."

Space forbids the quotation of many extracts from this interesting volume, but one more must be given, as being of special interest to readers of this Journal, apart from its intrinsic humour. Colonel Charles George Gordon was a Fellow of the Society, and a frequent visitor to 1, Savile Row. He was a man of very simple character, and extremely shy. " One day he suddenly addressed young Reeves in the map-room : ' Do you know, my boy, that the Prince of Wales sent his equerry to me the other day to invite me to dine with His Royal Highness ; and I said to him that that sort of thing was not in my line at all ; but if the Prince really wanted to see me, let him drop in and smoke a cigar in my rooms after dinner.' Reeves enquired timidly, ' But what did the Prince say to that, Sir ? ' ' Oh, he came along,' was the simple reply."

In 1913, the Society moved to its present home in Lowther Lodge. This move will always be associated with the name of Lord Curzon, the President to whose imagination and energy it was due. The scheme involved the sale of part of the open site, and the building of a lecture hall on the remainder. The war interfered with the completion of this plan, and it is only recently that it has been possible to carry it through. It was resolved to commemorate the Centenary by the completion of this much needed addition to the Society's premises. In Chapter XIV, Mr. Hinks describes the additions, which include a fine lecture hall, the first of its own, incidentally, that the Society has ever possessed, a council-room with other offices, a dignified library and map-room, together with much additional space for the reception and accommodation of Fellows.

Chapter XII, also due to Mr. Hinks, describes the war work of the Society. It is full of interest, and reflects great credit both on Mr. Hinks, who was responsible for the supervision, and on the small staff, mostly voluntary, who did the work. It included the very remarkable achievement of compiling more than 100 sheets of the 1/million map, covering practically all Europe and extending over Asia Minor to Arabia and Iraq. This map proved invaluable in the war and in the peace negotiations after.

The Record closes with a chapter of retrospect, illustrated by a historical chart, which shows in most interesting fashion the names and length of tenure of Presidents, Honorary Secretaries, and Secretaries, with the total membership of the Society and the number of elections in each year ; the last two being appropriately named the Prosperity and Popularity curves. Appendixes include a list of Presidents, the composition of the First and Hundredth Councils, and a list of veterans. There is an excellent Index. The illustrations are good, and our only regret is that limitations of space prevented the inclusion of more.

Altogether this is an admirable Record, on which we congratulate the author, his collaborators, and the Royal Geographical Society.

E.M.J.

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THE KITCHENER ARMIES: THE STORY OF A NATIONAL ACHIEVEMENT.

By V. W. GERMAINS.

(Peter Davies, Ltd. Price 7s. 6d.)

This book is written in a popular style, and can in no case be considered a book of reference. It is crowded with facts, but they are given in little order, and there is no index. Whether the facts are correct or not your reviewer is not able to judge, except in one instance, the date of embarkation for France of the 33rd Division. Here the author is certainly at fault, as our Tottenham Hotspurs were wallowing in the mud and chaos in front of Festubert some days before that time. It is to be regretted that he treats Lord Haig with such scant appreciation, but he has a natural antipathy for all " hoary " generals, and a positive dog-to-cat abhorrence of all Staff officers, which last may have been shared by many of the gallant members of the New Armies. In many ways this is an excellent book. The easy language of the author carries one forward at a racing pace. It is good that we should be reminded of this great crisis, perhaps the greatest in our history, in which so many of us may have played an infinitesimal part. The call of Kitchener to the War Office—his revolutionary opinion that the war would be a long one —his momentous decision to call out the New Armies—and the truly splendid response of British manhood to his call. Our author describes this as " the greatest strategic surprise known to history," and perhaps he is right. In language worthy of his great theme, he tells of the enthusiasm with which these citizen soldiers joined the Colours, of the stern persistency with which they carried out their training, amid innumerable difficulties and discomforts, of the splendid military force into which these enthusiasts were forged within a few months, and carries on the tale to its bitter end in the shambles, glorious in our annals, but still a shambles, of the Somme. Surely such a tale should never be forgot.

F.E.G.S.

A STUDY OF THE STRATEGY AND TACTICS OF THE SHENANDOAH VALLEY CAMPAIGN, 1861-1862.

ILLUSTRATING THE PRINCIPLES OF WAR, BATTLES DESCRIBED WITH SIX MAPS.

(Gale & Polden. 3s. net.)

In seventy pages, which includes the index, this book purports to study the strategy and tactics of the fighting in the Shenandoah Valley in 1861 and up to 17th June, 1862. The study unfolds in four chapters —Chapter 1 is a general summary, Chapter 2 a diary of events, in Chapter 3 the principles of war are " illustrated," and the last chapter contains " Comments on Battles."

Of necessity this condensed treatment of the valley fighting is bound to be sketchy, however carefully the book was written and edited; unfortunately bad editing and lack of clarity make parts of the book

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actually misleading. For instance, the Bulls Run River is not in the valley—Bulls Run was not a valley battle, but it is discussed and described as if it was. Again, there seems to be something wrong with the following passage on page 11—" Lincoln had done all he could to prepare for a successful war, but he did realize that detachments made for the defence of the capital reduce the fighting strength," presumably the offensive fighting strength : If so, did he ?

The sub-heads in Chapter 1 treat of reasons for the war, plans of campaign, mobility and training, bibliography, policy and strategy, geography, Jackson's operations, leadership and civilian interference, comparison of numbers on both sides, raids, personnel and armament. Each sub-head reads something like an indifferent answer to a promotion examination question, *e.g.*, discuss the value of raids from your knowledge of events in the Shenandoah Valley in 1861–1862—might be the question. Here is the answer !

RAIDS.

" Raids played an important part in this campaign. It is essential that they should be carried out with secrecy and rapidity. They can, however, never be decisive. They may cause inconvenience and lower an enemy's morale, but they cannot seriously effect a result. They must be relevant to the main situation." That is all, no mention of raids in the index. . . . Obviously the examinee knows nothing of any raids carried out during the campaign, and has relapsed into generalities.

The book is full of such generalities. I can, however, recommend it to any officer who, debarred by his social or sporting engagements from making a serious or reasoned study of his profession, wishes to equip himself with a veneer of military knowledge sufficient to enable him to bluff the authorities into retaining his services. He will find a set of usefully resounding platitudes on almost every page, and these he is recommended to underline and learn by heart. For instance—

" An important point to be noted in this campaign is leadership."

" The geography in the area of operations affected the strategy of the campaign."

" In this war also is brought out the lesson of mobility." Quite so, sir ! Quite so.

" Regulations teach us that we must learn from past experience, and that it is necessary to build on the past to make the future secure." Pass the port, sir, pass the port !

These are only a few nuggets, more are available ! !

As potted strategy for pallid students, the book fails to attain its object, if any.

E.E.D-S.

APPLIED MECHANICS FOR ENGINEERS (VOLS. I AND II).

By T. HODGSON, B.A., B.SC.

(Chapman & Hall, 9s. 6d. and 13s. 6d. respectively.)

These volumes will form part of a three-volume series, based on the lectures given at the City and Guilds Engineering College by Professor Henrici, to whose memory the work is dedicated.

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Vol. I is devoted to Graphical Statics, and opens with a chapter on the Theory of Vectors, which is the key to the subsequent investigations of Mass Centres, Co-planar Forces, Bending Moments and Shearing Forces.

These in turn lead up to chapters on Force Diagrams of simple Rigid Frames, and Virtual and Potential Energy.

Vol. II is devoted mainly to Dynamics, but contains chapters on the Differential and Integral Calculus, and the application thereof to dynamic problems.

Vol. III, which is still in course of preparation, will deal with Differential Equations and their application to electrical and structural problems.

Both the published volumes bear traces of their acknowledged origin, the text being more akin to the incoherent arrangement of lecture notes, than to the measured sequence of a normal textbook.

This slight defect is, however, amply counteracted by the careful grading of the very illuminating examples, provided for the reader's amusement at the end of each chapter.

Although there is no doubt that the series would be of the greatest value to any Sapper officer who wished to brush up his knowledge of Statics, Dynamics or Calculus, it cannot be so wholeheartedly recommended to those who wish to discover quickly the method of tackling an individual problem without a wholesale exploration of general principles.

The publishers are to be congratulated on the attractive way in which the volumes are presented.

The diagrams are numerous, and are inset where they are required; the text is very clearly arranged and culminates in an excellent index; the misprints are reduced to a minimum.

A.D.C.

REPORT ON THE RAILWAY SYSTEM OF TANGANYIKA TERRITORY.

By BRIGADIER-GENERAL F. D. HAMMOND, C.B.E., D.S.O.

In 1929, General Hammond was commissioned by the Colonial Secretary "to inspect and report on the Tanganyika Railways."

His report describes the organization and administration of the railway system, its financial condition and traffic services, with his criticisms and recommendations, and contains a survey of future policy and development.

The Tanganyika Railways consist of 128 miles of metre-gauge: the central railway from Dar-es-Salaam to Kigoma on Lake Tanganyika 773 miles, with a branch from Tabora to Lake Victoria 236 miles, and a line of 272 miles from Tanga to Aruska. There is also 15 miles of 2 ft. 6 in., and 78 miles of 2-ft. gauge, making a total route mileage of 1,374. The Railway Administration also includes the "Allied Services" of Marine Department, Dockyard and Slipway, Harbours and Wharves, Harbour Extension Works, and Electricity Department. The Electricity Department is not reviewed in this report.

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The Headquarters of the Administration is at Dar-es-Salaam; traffic working is organized on the Departmental System.

The several departments are dealt with in turn. The Engineering Department is in charge of new construction, surveys, and capital works, as well as of maintenance, which includes the maintenance of harbours, wharves and lighthouses.

The transfer of the latter duty to the Resident Engineer in charge of Harbour Works is recommended.

The report discusses the question of carrying out new construction departmentally or by contract, and is in favour of the latter, provided suitable local tenders are forthcoming.

The preparations for the construction of the Iramba Plateau line were too far advanced to admit of tenders being asked for from British firms.

The Loco Department has workshops at Dar-es-Salaam, Tabora and Tanga, *i.e.*, is organized in three practically self-contained districts.

The report throws an interesting light on the problem of training the local African drivers to a suitable standard of efficiency.

Wood fuel is used, except where on some sections the cost has risen to a point at which coal becomes cheaper.

While the figures given for operating showed on the whole satisfactory results, these were due in both Loco and Traffic Departments to personal exertion rather than system.

Such statistics as were maintained were meagre and their presentation too slow. On General Hammond's recommendation it has been arranged to form a statistics branch in the Accounts Department.

A proposal under consideration for the construction of a new single-ended traffic yard at Dar-es-Salaam is criticized, and alternatives suggested.

The report contains an interesting account of the working of the Marine Department, which includes buoying and lighting the coast, berthage and pilotage at Dar-es-Salaam and Tanga, and the operation of a steamer service on Lake Tanganyika.

An efficient Dockyard and Slipway are worked under the Chief Mechanical Engineer. A revision of the scale of charges is recommended which would make these self supporting.

The passenger and goods services and rates appeared to be giving satisfaction generally. The most important traffic carried is through traffic with the Belgian Congo. This, however, appears unlikely to increase, whereas the traffic from the Territory itself is increasing.

The financial situation of the railway is still weak, however. The cause is the small volume of business handled compared to the mileage maintained. This makes it particularly necessary for the Tanganyika Railways to increase their gross receipts and expand capital to do so.

Perhaps the most interesting chapter is that devoted to Future Policy and Developments. Funds have been allocated for the purchase of another steamer for the lake, and for improving the port at Kigoma. This will better equip the railway to meet developments which are taking place in the Congo and districts close to Lake Tanganyika.

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The report recommends that the Kenya and Uganda Railways should take over and work the Tanga line and port as agents of the Tanganyika Railways, and explains how economies would be thereby effected.

The proposals under consideration for the construction of new branch lines are discussed and the order of priority recommended.

The writer describes how the question as to which route should be chosen for the southern line has been clouded by the demand for a so-called "Imperial Link" between the Tanganyika and Rhodesian railway systems. No adequate justification for this, economic, administrative or strategic, has been advanced, and the choice should be made solely from consideration of which route will best develop the country to the south of the central line.

It is pointed out also how railway development is in the interests of the Territory, by bringing in new revenues, even more than to the advantage of the railway itself, so that it is right that the Territory should assist such enterprises.

L.M.

SURVEY OF INDIA.

GEODETIC REPORT, VOL. V.

From 1st October, 1928, to 30th September, 1929.

(Published by order of Brigadier R. H. Thomas, D.S.O., Surveyor-General of India.)

The Survey of India, judging from the published annual reports, appears to be more willing than any other survey organization of the Empire to give those interested in such matters the results of its work and investigations. No other department of the Empire engaged in this kind of work publishes nearly such full and detailed accounts of its doings. This is very evident to anyone who has to examine the reports of Colonial Survey departments, as contained in the summary given by the Colonial Survey Committee. It is extremely difficult to find out what has been done, especially the cost of the various kinds of work.

It is understood this is due to the very meagre information given by the surveys and to the want of system and uniformity in making out the reports. It is, however, encouraging to note that the question of producing uniform reports, giving specific information of what the different colonies are doing, was discussed at the last Conference of Colonial Survey Officers—it is hoped this will bear some fruit in the future.

During the period under review, the field operations comprised gravity observations in the South and East India, principal triangulation in Assam and Burma, and high precision levelling in northern India.

As the observations for the international longitude scheme of 1926, at Dehra Dun, were carried out with the prismatic astrolabe, they also yielded values for latitude, an analysis of which shows a marked fortnightly variation, which is not in agreement with similar results found

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elsewhere. The values have been plotted to show this variation with the age of the moon.

A series of observations for longitude was also carried out and the apparent changes have been shown by a graph. The extreme variation is about 0·2″, but the conclusion is "the curve is rather irregular, but the changes cannot definitely be ascribed to anything but instrumental error."

With regard to possible gravity variation, the results derived from the re-observation of certain old pendulum stations (some of which were made twenty-one years before) indicate that gravity values in India are stable *inter se*. But "whether they are stable in relation to gravity values in Europe is an open question." The different values of g, found at Dehra Dun each time a connection was made with Europe, is discussed. Dr. Oldham had doubts about the stability of gravity at Dehra Dun, on account of its nearness to the Himalayas. This seems to raise an interesting point; if isostatic equilibrium is still incomplete in Himalayan regions, as is probably the case, it might reveal itself by variations of g at Dehra Dun—but, on the other hand, isostatic adjustments may be so slow that they could only be detected over very long periods, much longer than have elapsed since observations were begun.

Chapter IV of the Report is devoted to a long and detailed discussion of Gravity and Deviation of the Vertical, in Section I, by Major Glerime, R.E., while, in Section II, Dr. de Graaff Hunter treats of the Development of Gravity Formulæ. Section III, by Captain Bomford, R.E., deals with the Indian geoid. The chapter is illustrated by many charts and is a valuable contribution to Indian geodesy.

Under the head of Triangulation, there are some important remarks about the behaviour of the Wild Theodolite in the field. Unfortunately, it is only possible to acquire portability, compactness, rapidity of reading and lightness, by introducing many complications which may go wrong in the field, perhaps hundreds of miles from civilization, as happened with the theodolites used by the Survey. We have always been doubtful about these complicated instruments, notwithstanding their many apparent advantages, and could not advise their use in their present form, except where an ordinary theodolite is carried as a standby. On the other hand, while they are in order, they give exceedingly good results.

In the chapter on Levelling, by Mr. H. P. Morton, among other subjects, are some interesting remarks on the errors of hill levelling of precision. The conclusion is that, of the many errors to which levelling may be subject, the most likely one is due to ignorance of the exact length of the staff which may considerably affect the closing error. Where the rise is considerable, "the remedy lies in the use of invar staves, which it is hoped to introduce shortly."

Chapter VII, Research and Technical Notes, by Dr. de Graaff Hunter and Capt. Bomford, R.E., deals with Dynamic and Orthometric Heights as applied to Spirit Levelling; Height Correction to Deviation of the Vertical; Comparison of Spirit-Levelled and Triangulated Heights.

The Report is accompanied by numerous charts and index maps with two folders, one showing average heights for India in 30-ft. squares,

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and the other an average contour map at 200-ft. intervals, except in certain flat areas where the interval is 100 ft.

A complete list of Survey of India publications is to be found at the end of the Report.

H.L.C.

STAR LISTS.

(American Geographical Society, School of Surveying, Publication No. 4.)

New lists of stars, for the use of observers with the prismatic astrolabe, have lately been issued which are of great importance to surveyors, and especially explorers, throughout the world.

These lists, which contain no less than 94,000 stars, have been compiled under the direction of Mr. Weld Arnold, of the American Geographical Society's School of Surveying. Their preparation and publication is due to the munificence of that well-known explorer and geographer, Dr. Hamilton Rice; than whom there is no more generous supporter of all things geographical as our own Royal Geographical Society has every reason to know.

The object of these lists is to render unnecessary the computation of an observation programme before beginning work with the prismatic astrolabe, or with Reeves' prism attachment for theodolites. The range of latitude with which the tables deal is from 60° north to 60° south. Ball and Knox-Shaw issued similar, though not nearly so extensive, lists in their Handbook of the Prismatic Astrolabe, also their lists are arranged by quadrants.

The tables are constructed for the star's passage across the 60° almucantar, for each degree of latitude between the selected limits. They give to the nearest minute the time of passage, the star's azimuth to the nearest quarter degree, its magnitude, designation and R.A. As every possible star appears in the lists they follow each other at intervals of only a minute or two.

At the end of the book is an article on the use and adjustments of Reeves' attachment, together with a set of forms and worked out examples, which should be appreciated by the beginner. For the benefit of explorers who intend to take with them a wireless time-receiving set, if he uses short waves between, say, 22 and 110 metres, he can obtain a set weighing only 5 kilograms, complete with spare batteries, tools and aerial.

The only criticism we have of this admirable book in its present form is that it contains, as far as the lists are concerned, a great deal more than any one surveyor on a particular job could require; he would, therefore, have to carry a certain amount of superfluous matter. We understand, however, that lists are also printed in pamphlet form by separate degrees of latitude for convenience in the field.

H.L.C.

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MAGAZINES.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1930. TOME II.—NOS. 1 TO 3 INCLUSIVE.)

Les opérations de l'Armée belge pendant la campagne de 1914–1918. The narrative of the events connected with the " Combats de Hautem-Sainte Marguerite et de Grimde " is continued in the numbers of the *Bulletin* under notice—Parts IV to VI inclusive. The account which appears in the first two numbers is based on Belgian records and publications, whilst that in No. 3 is derived mainly from German documents which have become available to the public. The Commander of the Belgian 1st Division, which, on August 18th, was in the neighbourhood of Tirlemont, received a verbal order at 2 p.m. to fall back on Louvain. Troops of the 2nd Mixed Brigade (whose outpost line covered a front extending from Neerlinter to a point N. of Vissenaeken) were at this time already engaged with the Germans advancing on Neerlinter, and the artillery of the Brigade had just received an order to open fire on a hostile force which had reached the outskirts of Wommersen. Details of the part played by various units of the 2nd Mixed Brigade during the " Combat de Hautem-Sainte Marguerite " are given in No. 1. The Belgians suffered heavy losses and were compelled to withdraw from their positions towards evening.

On August 18th, positions S. of Tirlemont (along the *Chemin de fer de Diest*) were held by units of the 3rd Mixed Brigade. At 1.50 p.m. German artillery opened fire on Grimde (a suburb S.E. of Tirlemont), and soon after 2 p.m. German infantry also appeared in front of the line held by the 3rd Mixed Brigade. About 5 p.m. this Brigade was also compelled to fall back. The measures taken in connection with the retreat of the Belgian 1st Division, and for its protection during the retirement, are dealt with in No. 2. In this number, an account is given of the fighting in which the 3rd Mixed Brigade was involved in the neighbourhood of Petit Overlaer and Cumptich ; and, in it, a sketch map is also provided showing the billeting areas assigned to the 1st Division for the night of August 18th/19th.

In No. 5 of the *Bulletin*, a brief account (based on German regimental histories, etc.) is given of the events of August 18th, 1914, from the German point of view. It was to the German First and Second Armies, together with the German II Cavalry Corps, that the task was given to cut off the Belgian Field Army from Antwerp. The German 2nd Cavalry Division, which was operating on the right of the German First Army (to which it was attached), crossed over to the N. bank of the Nethe at daybreak on August 18th, and pushed reconnoitring parties

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far to the N. and W. without coming into contact with any part of the Belgian Army. An Army Order, timed at 10 a.m. on the 18th, was sent to this Division with instructions that it should advance in the direction of Aerschot-Brussels. However, in view of the exhausting work already carried out by this formation on a very hot day, its Commander decided to rest his troops at Oosterloo, instead of carrying out the instructions issued to him. The German II and IV Corps reached the line Hersselt-Montaigu-Molenbeek-Cappellen without encountering any opposition. Troops of the German III Corps came into collision at Budingen with Belgian cavalry, which retired after a small skirmish; the left flank of this Corps reached Stock on the 18th without opposition. It was with the German IX Corps, which formed the left wing of the German First Army, that the Belgian 1st Division had to deal at Tirlemont.

The movements of the German 17th and 18th Divisions, and the operations of the latter Division, which led the attack against Tirlemont, are briefly described in No. 3. It is now evident that King Albert adopted a prudent course in not accepting battle on August 18th; the contest would have been an unequal one. The measures which were adopted by the Belgian High Command in fact upset the plans of the German High Command.

Chronique de l'Infanterie. Parts VI, VII and VIII of an anonymous contribution under the foregoing title appear successively in the numbers of the *Bulletin* under notice. In Part VI the employment of machine-guns is dealt with: the subject is reviewed in the light of an article by Lieut.-Col. von Schobert published in the *Militär Wochenblatt* for September 11th, 1929. Attention is also called to the instructions laid down in the Belgian and Italian official Regulations regarding the tactical handling of machine-guns. In this part of the original article, the Belgian doctrine in relation to the counter-attack is compared with the Italian and German doctrines on the same subject. In all three armies a distinction is made between the *contre-attaque immédiate* and the *contre-attaque d'ensemble*. The former term is applied to the case where an attempt is made to obtain a decisive result against exhausted troops by an immediate thrust before the latter have had time to familiarize themselves with the characteristics of the region into which they have penetrated. The latter term is used in relation to an attack which is made on the supposition that the enemy has not yet had time in which to establish himself in new territory and properly to organize a defensive position therein. Matters relating to anti-gas training are also briefly touched upon in No. 1 of the *Bulletin*.

"Mechanization" and "motorization" are dealt with in Parts VII and VIII. The term "mechanization" is employed in the original article to denote the introduction in the armament of troops of a continuously increasing number of "automatic" weapons with a view to augmenting the fire effect of the arms with which troops are equipped, whilst at the same time a reduction is obtained in the numbers of the men which are required in the firing line on a front of a given extent. The term "motorization" is employed to signify the increased use of all forms of mechanically-propelled vehicles, whether of the armoured or the non-armoured type.

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Part VII deals with mechanization : the bearing which this subject has on the new types of organization proposed for infantry units is briefly discussed therein.

Part VIII deals with motorization : the experiences of the Great War in relation to mechanically propelled vehicles and the requirements in relation to mechanical transport are briefly touched upon therein.

Les Opérations de nuit. The original article is contributed by Col. Denayer, Belgian General Staff, to No. 1 of the *Bulletin;* he discusses therein the instructions on this subject contained in the Belgian *Le Service de campagne* and *Règlement sur le combat de l'infanterie.* Details are given by Col. Denayer of night attacks carried out by Belgian and French troops during the Great War ; the conclusions to be drawn from these operations are also summarized by him.

La Siège de la Citadelle d'Anvers en 1832. Parts IV, V and VI of the article by Major Delvaux under the foregoing title appear successively in the numbers of the *Bulletin* under notice. Holland was not willing to accept the decision taken at the Conference of London. King William felt that the retention by the Dutch of the Citadel of Antwerp was a dynastic as well as an international question. He had acquired rights in Belgium under the Treaty of Vienna, and, in his view, it was necessary that all the signatories to this Treaty, and not a very small minority of them, should act in the matter, if an important change in the status of Belgium was really required. In consequence, a critical situation came into existence. The defensive measures adopted by Holland and particulars of the belligerent forces are given in No. 1 of the *Bulletin.* At this time the Dutch Field Army consisted of 45,000 men, 3,000 horses and 104 guns ; there were in addition fortress troops and volunteer corps. Including the land forces detailed for the defence of Antwerp, Holland was in a position to put 105,000 men in the field in a European theatre of operations.

The Dutch garrison of Antwerp and its forts consisted of 164 officers, 4,324 O.R. and 145 guns. The Dutch also had small naval forces near Antwerp and Flushing (33 boats in all carrying 4,025 men and 675 guns) ; other Dutch naval forces were stationed at the Helder and at Helvoetsluys.

The French *Armée du Nord* consisted of 65,000 men, 14,000 horses, 72 field-guns and 80 siege-guns. Some 16,000 French troops, in addition to the artillery and the sappers and miners, were employed in the siege operations against Antwerp ; they were covered by another force of 29,000 men—the personnel of the parks and a reserve force of 13,000 men are not included in these figures.

The Belgian *Armée d'Observation* consisted of some 67,000 men, 6,800 horses, and 78 guns. Including the *garde civique,* Belgium was in a position to put 105,000 men (out of a total population of 3,800,000 persons) in the field. The Franco-Belgian force in the Antwerp theatre outnumbered the Dutch defence force by approximately 25,000 men and a few guns.

The Siege Park of the French *Armée du Nord,* which was mobilized on October 1st, 1832, contained 36 siege guns and 14 howitzers of various calibres. This armament was at once added to by drawing on the

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reserves at certain French fortresses. Thereby, the siege train was increased to 80 guns and howitzers and 6 wall-pieces.

The French siege train entered Belgium on the morning of November 15th; its personnel was provided by 14 artillery companies (of 120 men each), 6 companies of *sapeurs-mineurs*, an engineer detachment and a bridging brigade. The waterways of Belgium were utilized for the transport of guns and other material to the front, and much time was thereby saved.

Part IV concludes with an account of the early phases of the French operations against the Citadel, and the part played by the Dutch naval forces against the besiegers.

The operations against the Citadel of Antwerp fall into two distinct periods; the first of them extends from the night of November 29th/30th, when the first parallel was opened, to the night of December 13th/14th, when the St. Laurent lunette was captured; the second extends from the latter date to that of the capitulation. The text of the Convention entered into between the French and Belgian authorities on November 15th, 1832, providing for military co-operation, is set out in Part V, which also contains an account of the opening of the first and second parallels and of the batteries of the first artillery position; the measures taken in the Citadel by its garrison to guard against a surprise attack are also described therein.

Fire was opened by the artillery of the defence at noon of November 30th. An explanation of the circumstances which led to this first act of hostility is to be found in the correspondence which passed between Gerard and Chassé on November 30th; on this date the former demanded the surrender of the Citadel. This correspondence will be found in No. 2 of the *Bulletin*.

The task of arming the French batteries proved to be a difficult and perilous one, and it was not until the morning of December 4th that the guns were ready to come into action; at 11 a.m. on this date, 85 guns and howitzers opened fire against the defences of the Citadel. Some of the enemy's guns were dismounted, and a good deal of damage was done by the French artillery; the bombardment is described in No. 2.

The operations of December 6th to 13th inclusive are dealt with in Part VI. On December 6th, the supply magazine in the Citadel was set on fire by the French artillery; on the following day the powder magazine was blown up, and on the 8th the main barracks were destroyed by it. The Dutch garrison displayed a good deal of activity, and did much damage to the French trenches; the French sappers spent a busy night (on the 8th/9th) repairing the damage. The Dutch carried out a sortie on the evening of December 10th against the French lodgment on the Toledo bastion, and succeeded in destroying French saps. However, the French soon recovered the ground lost by them.

A description of the operations resulting in the capture of the St. Laurent lunette on December 13th is contained in No. 3 of the *Bulletin*. Part VI of the article concludes with extracts taken from the reports relating to these operations made by Serjeant Reymering and Lieut. Boers.

Les aspects militaires de la Révolution de 1830. Parts IV, V and VI of

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the article under the foregoing title by Capt. Wanty are published successively in the numbers of the *Bulletin* under notice. The narrative of the events of September, 1830 are continued in Part IV. On September 23rd, Prince Frederick endeavoured to treat with the leaders of the Revolution, in the hope of restoring order without resort to force; he sent Lieut.-Col. de Gumoëns to Brussels for this purpose. An account of the negotiations, which proved abortive, is given in No. 1 of the *Bulletin*. It was recognized by the leaders of the Revolution that it was necessary to constitute some authorized body which should become responsible for any military and administrative action which might be decided upon. Accordingly on September 24th, a *Commission administrative* was created and assumed the direction of affairs.

Hostilities were resumed on September 24th: an account of the local operations which followed thereupon; the spread of the revolt to the Provinces; the setting up of a *Gouvernement provisoire* (to deal with Belgian affairs); and the early measures taken by the latter, are dealt with in Part IV. The Dutch met with reverses in the early days of the fighting; at the time, the majority of the men serving in the combatant units stationed in the revolting Provinces were Belgians. Defections in these units had been rare up to September 26th; after that date they increased largely. The situation became so serious that Prince Frederick who had been playing the part of a Conciliator, found it necessary to seek further instructions from The Hague.

The early military activities of the *Gouvernement provisoire* are dealt with in Part V. Van Haelen, a Spaniard who had had much experience of street fighting, had been appointed Commander-in-Chief of the Belgian forces; the early successes with which he had met turned his head and brought him into serious conflict with the *Gouvernement provisoire*. The friction continued to increase, and on October 5th Van Haelen was placed on the retired list.

The *Gouvernement provisoire* soon found it necessary to delegate its executive powers, and accordingly appointed a *Comité centrale*, which dealt directly with the *administrateurs généraux* who were placed in control of the special committees made responsible for the conduct of the War, for Supplies, for Public Safety and for Finance. The activities of the Government in relation to the creation of an independent Belgium, and the events which took place in the Provinces, are described in No. 2 of the *Bulletin*.

The successes of the Belgian volunteers at Brussels gave the *Gouvernement provisoire* the time necessary in which to build up the framework of an Army. Some of the commanders of the volunteer units who had already distinguished themselves in the early days of the Revolution were authorized to raise new units. An account is given in Part VI of the creation of Belgium's new Army and of the operations in which it took part for the liberation of Antwerp.

Two Belgian columns were eventually formed and advanced on Antwerp; they made junction at Vieux Dieu on October 24th. They continued their advance, meeting with opposition from Dutch troops, and were finally brought to a halt on the 26th before the ramparts of the Citadel.

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A history of the events in Antwerp between August 28th and November 5th will be found in No. 5 of the *Bulletin*. The revolutionaries entered the city on the morning of October 27th, and at once sent a flag of truce to the Citadel demanding a formal surrender of the Dutch defences. Eventually, on November 5th, an armistice, the terms of which are set out in No. 3, was duly signed by the Dutch military authorities and the representatives of the *Gouvernement provisoire*.

L'aérostation de protection. The original article is contributed to No. 3 of the *Bulletin* by Capt. Comdt. Hupelier, who gives a brief account of the development of aerial entanglements during the Great War. He states that this form of passive defence against aerial attacks was introduced by the Italians, who used it first at Venice ; it met with success, and, later, other belligerent Powers adopted this arrangement and developed it further. This form of aerial defence was extensively used during the final phase of the Great War.

W.A.J.O'M.

REVUE MILITAIRE FRANÇAISE.

(*July*, 1930.)—Commandant Larcher begins "*La campagne du 1er corps en Belgique*" in this number. This corps, commanded by General Franchet d'Espérey, was on the left of the French Fifth Army, and was frequently acting as an isolated force. This instalment only deals with the first few days of the War, when the corps advanced to the line of the Meuse, where it took up bridgeheads about August 11th, 1914. The writer prefaces his description of the operations with remarks on the high standard of training instilled into his corps by Franchet d'Espérey and points out that success attended his actions, as far as was possible, during this critical stage of the War.

Lieutenant-Colonel de Boisboissel completes "*Les opérations au Maroc*" in this number. This final instalment is more interesting for a promotion examination candidate than for the casual reader, as it deals with the various staffs and services required for mountain warfare. Apparently the French used signal equipment of much the same kind as our own, while there is the ever-present resemblance to the N.W. frontier of India in the supply and transport services. The writer points out particularly that a base must be ready before it is used for issue ; this is not realized by a great many staff officers, unfortunately. The instalment is illustrated by three interesting photographs of events in Morocco.

"*Réflexions sur le règlement anglais de* 1929," by Capitaine Morel, is a very interesting article on our *F.S.R. II*. The writer puts himself in the position of an Englishman, rather than a Frenchman, and so is able to find a reason for our present-day teaching. As he points out, our intervention by land in the Great War was contrary to our principles ; the normal use for our army is to provide a true Expeditionary Force, small but well trained and well armed, and backed up by our industries at home. As is pointed out in the opening chapter of *F.S.R. II*, the use of armed forces in England is bound up with the political strength of the country, but armed forces in no way represent the total strength of the country. Here England differs obviously from France, who, once

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she is engaged in a European war, must mobilize all available men for her army, which is her first and far the most important line of defence. Captain Morel therefore points out that our present-day emphasis on armoured vehicles and our search for flanks in army operations naturally follows the instinct of the country; and though he plainly realizes that similar considerations cannot bear so much weight with the French, he evidently thinks that it is to our advantage to follow up these instincts. In conclusion, the writer draws attention to the fact that, four or five hundred years ago, the English infantry destroyed the stock of the armoured cavalry, which had been so long the greatest power in war. He then goes on to say that it will be interesting if the English produce a fresh revolution in war, by the general introduction of armoured fighting vehicles, and he points out that *F.S.R. II* points towards this second revolution, though with very great prudence.

"*Une étude de guerre de montagne en Afrique du Nord*," by Commandant Peyronnet and Capitaine Jousse, begins in this number. Between 1830 and 1840, the French carried out various expeditions in Algeria, and in 1929, Franchet d'Espérey, Inspector-General of Northern Africa, had similar operations carried out with modern troops, as a memory of the original French advances. This instalment is devoted to a short summary of the expeditions from Algiers to Médéa, which was the key of the routes to the south. It was not till 1840, when the French had developed a policy in Northern Africa, that it was decided to occupy Médéa permanently, and this was carried out by Marshal Valée successfully, against the opposition of the native tribes. The instalment is illustrated by a sketch map.

Capitaine Michel begins "*Monthyon*" in this number. The 55th Reserve Division took part in General Manoury's operations on the extreme left of the line on 5th and 6th September, 1914, and the writer describes these operations, partly from their own interest, and partly because this, being a reserve division, resembled those mobilized later on during the War. The instalment deals with the general condition and the advance of the 55th Division. The men were very tired by the long retreat, and had lost most of their equipment, but the order to advance invigorated them enormously. Unfortunately, orders were issued so late that there was simply no time for them to get through to the forward troops, thereby disorganizing the advance considerably. We must realize that it is not only with reserve divisions that this occurs. The instalment is well illustrated by a map, photo and sketch.

(*August*, 1930.)—Commandant Larcher continues "*La campagne du 1er corps en Belgique*" with a description of the fight at Dinant and of Franchet d'Espérey's plans to meet the main German attack. The Germans had effected an entry at Dinant when a well-timed counter-attack, carried out by infantry and artillery in close co-operation, drove them out. When the main German advance was expected, Franchet d'Espérey's plan was to draw the enemy on with his 1st Division and then to counter-attack with the 2nd. The instalment closes with the force of 30,000 men awaiting the German advance.

"*L'aviation de bombardement*," by Colonel Aubé, is a discussion of the present situation of aerial attack. This is always an important question,

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particularly as the civil population is interested as well as the soldiers. As the writer points out, the railway station of Metz-Sablons was frequently bombed during the war, and yet little interruption to the railway traffic was caused. For future bombing to be more efficient, it is necessary to study the question thoroughly in peace time. Colonel Aubé discusses the value of bombs as opposed to shells, and the different targets to which they are suited, and finally comes to certain conclusions. At present, with peace-time effectives, he does not consider that bombing will have decisive effects, although reserves of the enemy may be immobilized provided that objectives are not multiplied. There are still many targets, such as troops on the march, which are difficult to bomb efficiently; so the writer points out that research must be continued. Some new invention may greatly increase the value of bombing, and then the whole subject must be considered afresh.

"*La campagne du Cameroun*," by Capitaine Girard, begins in this number. Naturally at the outbreak of war Great Britain, France and Belgium all felt drawn towards the German Cameroons; the difficulty was to find a combined plan. The French started by protecting the three or four possible roads of ingress by which the Germans could work their way into the French Soudan; when this was done they naturally turned to the offensive. After discussion between the British and French Governments a plan was agreed on and put into operation. Unfortunately it took days or even weeks for telegrams to get from one place to another; as a result columns failed to meet each other, and the general plan was more honoured in the breach than in the observance. This instalment takes us up to June, 1915, when a British and French column, who had succeeded in meeting earlier in the year, had really begun to make some progress. The article describes the action of the different columns and their efforts to carry out the general plan, and a sketch map is given.

"*Une étude de guerre de montagne en Afrique du Nord*," by Commandant Peyronnet and Capitaine Jousse, is completed in this number. The actual manœuvres between the blue and red forces are described shortly, and then the actual operations of 1830–40 are compared. There is no particular interest in the article. It is illustrated by a map, which does not, however, give a very clear idea of the difficulties of the country.

Capitaine Michel continues "*Un combat de rencontre; Monthyon*" in this number. An encounter battle is a true description, part of the French 55th Reserve Corps were absolutely taken by surprise by a burst of shelling during their advance. At the same time the Germans opposite them were extremely short of information, and actually launched an attack for reconnaissance only. Thus the battle of the Ourcq began on this part of the front, neither side knowing what the other was doing. After describing the early part of the fighting, the writer points out how both sides were at fault. They had no organized aircraft and their divisional cavalry was weakly handled. Hence they came upon each other, but unfortunately the Germans saw the French first and were able to develop their attack. This instalment is well illustrated by two panorama sketches, apart from maps and photographs, so that the detailed account of the action can be easily followed.

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(*September*, 1930.)—Commandant Larcher completes "*La campagne du 1er corps en Belgique.*" This corps, which had started with an offensive, had to retire before the Germans after Namur fell, and this instalment describes its withdrawal. Thanks to the Corps Commander, General Franchet d'Espérey, who had trained his corps to a high state of efficiency, the retreat from Belgium was effected with little loss either of men or morale. At Oirhaye, where the Germans advanced on 23rd August, 1914, a brilliant counter-attack, led by General Mangin, drove them back; after this action the withdrawal suffered little from the attentions of the Germans. The writer is evidently a great admirer of both d'Espérey and Mangin; and his description of the presence of mind and coolness of them both, under very trying conditions, is worth reading.

Commandant Delmas begins "*La manœuvre de contre-attaque*" in this number. The article is one for serious study rather than for careless reading. The writer considers and expands the regulations for the counter-attack, and discusses every possible item that may arise. This article deals with the immediate and deliberate counter-attacks, not with the passage from the defensive to the offensive; and this instalment is confined to the immediate counter-attack, which is illustrated by an example from an action in Alsace.

Capitaine Girard completes "*La campagne du Cameroun.*" The stages of the Allied attack described in this instalment may be divided into three: the unsuccessful advance of 1914–15, the successful advance of 1915–16, and the final occupation of the country. The early operations in the Cameroons had consisted of isolated actions in spite of inter-allied conferences; now an effort was really made to control the attacks of the different columns. The first effort was completely checked, but in 1915–16 a real advance was made, and both the British and French columns achieved very considerable successes. After this, the final clearing up of the country was not so difficult, although the German resistance was always most determined. The casualties were considerable in proportion to the number of troops concerned, being about 25%. Unfortunately there is no map with this instalment, which teems with outlandish names, so the actual operations are hard to follow. The writer considers that good though the help of the British and Belgians was the French carried the brunt of the day, and they were rewarded by the big proportion of the country awarded to them at the Treaty of Versailles.

"*La politique des grands Caïds au Maroc*," by Colonel de Mas-Latrie, is an interesting article on the French policy in Morocco. Before the Great War, the French governed a large part of the country by the establishment of powerful chieftains, supported by French money and arms, who controlled their territories completely as long as they behaved properly. This worked very well, and the effects of the Great War were not felt until 1916, when a Dr. Pröbster, a German Consul, started to give trouble. He disappeared fairly soon, but a revolt did take place before all disturbances were crushed. The difficulty of this system was that the chiefs, or Caïds, levied a toll on conquered tribes to find money to carry out some of the duties laid on them by the French. To try to

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conciliate the people it eventually became necessary to modify and centralize the method of governing the country. This was fortunately made easier by the death of some of the original chiefs, and the French are now gradually taking over the control of the country themselves.

In the third instalment of "*Monthyon*" Capitaine Michel describes the second French attack on Monthyon, and the beginning of the retreat of the German Fourth Corps, protecting the right flank of Von Klück's army. The writer's conclusions are interesting. He points out that although the French mission was a vigorous offensive, the lack of air reconnaissance gave far too little information. On the other hand, Von Gronan, commanding the German Fourth Corps, gained his information by fighting, and then retreated in such a formation as to protect the German First Army. This corps was in a very important position, and it was successful in preventing a severe blow being struck against Von Klück. Attention is drawn to the failure of communications, which was particularly marked.

H.A.J.P.

REVUE DU GÉNIE MILITAIRE.

(*July*, 1930.)—In an article called "Communications in Modern Warfare," Captain Gazin describes the arrangements made by the German 7th Army during their attack across the Marne and subsequent retreat from the Marne to the Vasle in July, 1918. He derives his information from a book by Von Baur, who was in command of the railway troops of the 7th Army in June, 1918. Apparently the German operations would have been impossible without the construction of a 10-km. length of railway connecting the Laon–Reims and the Soissons–Reims lines, Soissons being inaccessible owing to the damage to the Vauxillon tunnel and Reims being in the possession of the French.

"The Engineers and the inundations in the South-west" is a description by L.D. of the repair of a 60-metre breach in the high road between Moissac and Castelsarrasin carried out by the 3rd Regiment of Engineers.

A.H.B.

MILITAERWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*November–December*, 1929.)—This is an anniversary number, and celebrates the close of the sixtieth year of publication of the *Mitteilungen* by printing the congratulations of the leading German, Hungarian and Austrian military periodicals, as also those of the Minister for the Army, Vice-Chancellor Vaugoin; who himself has put up no mean record by completing his tenth year of office. A résumé of Austrian military publications since 1808 gives some account of the *Mitteilungen's* forbears, and of its own vicissitudes. Starting in 1870 as a paper for Artillery and Engineers only, it widened its scope and took its present

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title in September, 1920, when the new Austrian army was formed. Since the latter date the paper has increased steadily in size from a volume of 254 pages to one of 960. If this increase mainly reflects the increased importance of and interest in science, it still shows that the *M.u.T.M.* is filling the bill. The magazine is first-class in every respect. It issues valuable special numbers like those on air-fleets and mountain warfare, and independent publications of wide interest like "The World's most important Campaigns," which contains nearly 200 maps and costs only a few shillings. Only the greatest keenness and the services of officers willing to forego payment could produce such an achievement. That the *Mitteilungen* survived the war is a matter of congratulation; that it weathered the break-up of the Hapsburg Empire and the disappearance of the old Austro-Hungarian army is still more wonderful.

The Official Austrian History of the War. Major-General Kerchnawe deals with the third number of "Austro-Hungary's Last War," which is being issued in 30–36 parts. The number here reviewed covers to a certain extent the dramatic climax of the 1914 campaign, on the issue of which depended the four succeeding years of hardship—the battle of Ravaruska-Lemberg, the first siege of Przemysl (*anglice* Chaymisl, as near as makes no difference), and the October offensive culminating on the San and at Ivangorod, in which for the second time Conrad von Hoetzendorf sought a decision, this time in close association with the German 9th Army. The parallels with the Marne are striking. Field-Marshal Conrad himself wrote ten years later, "This breaking-off was no tactical necessity, for the situation was not bad. The operative circumstances were, however, untenable. And it is certain that in the breaking-off of the battle in the dark days of Ravaruska very much longer was waited than at much the same time in the days fraught with decision on the Marne." Gen. Kerchnawe says, "The old Austro-Hungarian army did not leave this bloody theatre defeated: Russian arms and the Russian soldier had not conquered there; nor had Russian leadership. The battle of Lemberg–Ravaruska was no more than the inevitable termination to the sad and pitiful chapter of complete political lack of purpose, passivity and reprehensible neglect of the army, 'the resultant of all political lack of vision and lack of clearness of thought' in the decades preceding the war, as the Official History discreetly but clearly shows. The conquered of Ravaruska were the leading statesmen and political leaders of Austro-Hungary *before* the war. It is they who have the sad fame of having made smooth the enemy's road to final success. The Russians were hardly less astonished at their 'victory,' than the French were at the wonder of the Marne."

The Brain of the Army—a review of a Russian work of three volumes by the Chief of the General Staff, Schaposchnikoff. The author investigates the position of the General Staff before the war, the place it held in the nation as supreme director of the army, and specially inveighs against the encroachments of the General Staff upon the internal and external political life of the State. In order to be able to work out clearly his doctrine and conclusions for the future, Schaposchnikoff takes an example out of history, and rejecting Russians, Germans, French and

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British alike, selects for this purpose, owing to the greater wealth of records available, the activities of the Austro-Hungarian General Staff and of its Chief, Field-Marshal Conrad, based upon the latter's memoirs.

Although an ex-officer of the Imperial Army—he was a Colonel and Chief Staff Officer of a Corps in 1914—Schaposchnikoff is an exponent of the ideas of the present Russian form of government, and opposed to the "capitalist" Western powers. All armies and all General Staffs before the war are labelled by him "capitalist and imperialist." He runs down what he calls the "War-mandarins" and the "G.S. tin-gods." His Austrian reviewer takes him to task for this, and doubts whether the new type of Chief of the General Staff, as sketched by Schaposchnikoff, will ever do as much as the "War-mandarins," like Field-Marshal Conrad did "in the greatest war of a thousand years."

German Fate at the Breakdown, by Gen. Ratzenhofer. This title, like that of the same author's article in the last number, needs elucidation. What it means is: an enquiry into the fate of the officers and men of German descent serving in the Austro-Hungarian army at the end of the war. A published statement that there were 97,000 such, who were taken prisoner, has stirred Gen. Ratzenhofer to much research and statistics. He points out that of such a total there would not be more than 13,600 who belonged to front-line troops. He points out further that hostilities ceased on the Austrian side on November 3rd, and that between that date and November 11th the Italians, by sending forward small detachments on the main routes to intercept the masses streaming homewards, took over 400,000 prisoners, mostly without resistance. Both facts should help to draw the sting.

Army-leaders of the Entente in the World War. Three obituary notices on the Grand Duke Nicholas, Cadorna and Foch.

A Contribution to the history of Armoured Trains, by Major Mayer. This article is based upon the British *Detailed History of the Railways in the South African War*, a study of which has left Major Mayer convinced that, even making all allowances for the differences between a South African and a European theatre of war, the introduction according to plan of a sufficient number of powerfully gunned armoured trains in European warfare would be valuable under the most varied circumstances. He cannot understand why at the outbreak of the Great War the Central Powers had neglected to increase the fighting strength of their cavalry division by including in them armoured trains.

The Use of Heavy Machine-guns and Infantry Offensive Spirit, by Major-General Büttner. The author compares the heavy machine-gun with the original idea of a machine-gun, viz., that the latter was merely a weapon with the ballistic properties of the infantry rifle, which on account of the rapidity of its fire was able to develop from a small space a great fire-power, and at short and medium ranges to work destructively within a short time against living targets in the open. These requirements are met to-day by the light machine-gun. Over and above them, the heavy machine-gun is able to keep down an enemy under cover by continuous fire for some considerable time; by suitable choice of firing-position, to fit the trajectory to the terrain; to obtain the utmost use out of the infantry fire-power up to the limit of its capacity; under

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certain conditions, to shoot over areas and one's own troops without danger to the latter, and at long range to cover even unseen spaces with a dense cone of fire, formed to suit the occasion. The moral effect of the heavy machine-gun both on the enemy and on one's own troops is also far greater than that of the light machine-gun. The manifold properties of the heavy machine-gun open up varied possibilities of employment. Wilfully to forgo these would be like driving a car at pedestrian pace. The heavy machine-gun is thus taken as being indispensable.

Turning to the offensive spirit the author analyses it, but does not connect it with the heavy machine-gun in any particular way, as might be expected from the title of the article. The heavy machine-gun is one of the " means of supporting the attacking infantry, through the judicious application and the best possible utilization of which the leader must create the foundations upon which the offensive spirit is built up."

The Development of Artillery Material since 1914. When Major Heigl started this series of excellent articles in May, 1927, he deferred the subject of field-guns with splayed carriages both for the opening up of other sources of information and to allow for a development then in progress. He is consequently now in a position to show that no field-guns other than with splayed carriages are any longer built. It is impossible in this respect, both historically and constructively, not to think of the veteran, who brought about a revolution of field-gun construction, the French 75-mm. field-gun C 97 of Deport, which after over thirty years is still so good to-day that its replacement is not yet *en train.* Instead of a gun which after firing had to be brought back again laboriously into position and re-aimed, there appeared in 1895 a field-gun firmly nailed to the ground and capable of firing twenty-five rounds a minute. It had the first barrel-recoil fit for service in the field and the first Q.F. breech-block.

Germany and Austria were ten years behind in following suit. In 1911 the same firm followed with another epoch-making invention, the splayed carriage, embodied in the Italian 75-mm. Deport gun M 11, which also had an extraordinary complication in a field-gun, double recoil. In Austria as elsewhere the invention either received no attention or was contemptuously dismissed until about 1920. It was then that on land the 155-mm. Filloux gun became the pioneer of the splayed carriage principle.

Progress since 1914 is then shown by descriptions of the following :—

The British 18-pr. field-gun Mk. IV on Mk. V Deport carriage, system Vickers (three photographs and three drawings with names of parts).

The 75-mm. Schneider field-gun M 18/22 (two photographs).

The American 75-mm. field-gun M 23.

The 75 and 76·2-mm. field-guns, design M 29 Bofors (two diagrams and two detail drawings).

The Japanese 75-mm. field-gun.

The 85-mm. Schneider gun-howitzer, for the Greek army (photographs of firing-position and on the line of march).

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The 9-cm. Bofors gun M 29 (two photographs of firing-position, front and rear, and one on the line of march).

The 75-mm. Schneider L.F.A. field-gun L/40 M 26 (photographs of firing-position and on the line of march).

Included in the above-mentioned descriptions are a list of data in each case and an opinion of the gun's powers, appearance, peculiarities, etc.

Two Types of Infantry-Gun by Vickers-Armstrong. The many demands upon an infantry-gun to-day can scarcely be solved by one calibre. Hence various firms have, in order not to complicate unduly infantry equipment, built guns with two barrels, either having the two barrels at the same time next to each other, or one above the other, or capable of being quickly interchanged, or so constructed that the barrel of smaller calibre can be inserted in the larger barrel.

This article by Capt. Däniker, of the Swiss Army, known to readers of the *R.E. Journal* by his articles on machine-guns, introduces to us a quite original type of infantry-gun with two barrels—the Vickers 44-mm. and 60-mm. infantry-gun—with full descriptions, drawings, list of data and photographs. There is also described the " Ordnance Q.F.S.A. 47-mm. 20 calibres infantry-gun " by the same firm. In this case there is a single barrel, and hence a medium calibre had to be selected, which allows of easy comparison with the Beardmore, Pocisk and other infantry-guns.

The Responsibility for the World War.—Reviews a book by C. Raymond Beazley, an English professor of History connected with the Labour Party, which is appearing in parts in the *Berliner Monatshefte.* As evidence of a presumptuous attitude towards Germany on the part of many Englishmen, we are asked by this gentleman to accept the statement of an English statesman, " The patriotism of an Englishman is one of the noblest feelings of our nature, but the patriotism of a German is the last refuge of a scoundrel." This egregious utterance, without acknowledgments to Dr. Johnson, has now been seriously accepted and is as seriously broadcast. Verily, sarcasm is a dangerous tool. Professor Beazley also says that from 1901 English politics were conducted more and more under the device *Delenda est Germania*, a perversion of Cato's *ceterum censeo* which is unwarrantable, incapable of proof, and most misleading. It is difficult to see what good a book of this sort can hope to do. If the samples given are fair ones, the book is more likely to promote misunderstanding than remove it.

" All Quiet on the Western Front "—a deception! This pamphlet by Müller-Scheld is recommended, as a corrective, to all who have read Remarque's book, by Lt.-Col. Regele, the author of " The Forcing of the Save " (*R.E. Journal*, March, 1930), who gives it first place amongst all the indignant rejoinders that work has called forth.

" July, 1914," by Emil Ludwig. " In all his books this writer moves ceaselessly between history and romance, between reality and phantasy, and between the desire for truth and tendenciousness. In none of his books has he wandered so far from the historical foundation as in " July, 1914." It is suited to an age which likes its history in piquant style. The book is quite cleverly written railway reading—no more ! "

F.A.I.

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HEERESTECHNIK.

(*December*, 1929.)—*The Fourth General Meeting of the German Society for Photogrammetry*. This took place in October last at Berlin. The following is a list of lectures given :—

(*a*) Résumé of the technical and economic problems of small-scale survey by aeroplane photographs.
(*b*) Results of the trial survey by means of the panorama camera of the Photogrammetry Co., Ltd.
(*c*) Photogrammetry on journeys of exploration, with special reference to the Russo-German Alai-Pamir Expedition.
(*d*) The degree of reliability of the Hungarian photographic maps.
(*e*) Photogrammetric surveys with recording theodolites.
(*f*) Cinematogrammetric determination of aeroplane movement.
(*g*) Processes for the determination of the position of aircraft in flight.

In the first and second lectures the different opinions were represented, that for small-scale map-making, as in colonial territories, long-focal distance cameras should be used, as better for bringing out detail ; and against this, that short-focal distance cameras with a wide angle are best, so as to bring as much as possible on to one plate, and thus get a better general view. The lecturer, Aschenbrenner, showed a series of photographs taken by an instrument of his own design, the panorama camera, which is specially suitable for making small-scale maps in hitherto unsurveyed country. The pictures taken by it permitted, even at 1 in 65,000, easy recognition of the detail necessary for map-making.

The panorama camera saves time and money, since the photographs taken by means of it are about forty times as large as long-focal distance photographs taken at the same height. As regards accuracy, a strip of country 30 km. long was bridged over by six shots of the camera. Mapping was carried out at 1 in 100,000, starting and finishing points being fixed. Twelve control points distributed over the area had an average position error of 34 metres.

Even in countries already surveyed it is easy to think of cases in which, principally to save time, the panorama camera can be usefully employed.

The panorama camera of the Photogrammetric Co., Ltd., of Munich, has been made by C. A. Steinheil Sons under the direction of Ascehnbrenner. It is a multiple camera, consisting of one central and nine side cameras, so arranged that in one exposure simultaneously nine photographs are taken on one and the same plate, 18 x 18 cm. Focal distance is about 5½ cm. The nine pictures will, when pieced together, be found slightly to overlap. A transforming apparatus is now needed to transform the side-pictures on to the plane of the centre-picture and on to the scale of the centre-picture. Through this transformation one obtains a complete picture 27 x 27 cm., corresponding to one taken with a picture-angle of 120° and the same focal distance. The area covered by a single picture is a square, the length of the side of which is about five times the height of the aeroplane. For carrying out picture-triangulation another

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instrument is required—the transferring apparatus. The company proposes to carry out with this camera a trial survey of an area of 10,000 qkm. (62½ miles x 62½) under official control.

As regards lecture (*e*), Dr. Fuss showed his recording theodolite with photographic reading of angles, made by the firm of Carl Bamberg of Friedenau, Berlin. It determines the vertical and horizontal angles of the line of sight of a quickly moving object at desired intervals—down to half a second. A chronograph is used with it to record on the film the time of observation next to the reading of the angle. These observations are carried out from two or more stations, and simultaneous registration is arranged for at all stations by a common circuit which includes a clock.

Dr. Fuss subsequently showed a development of his recording theodolite in the kinotheodolite of the Askania Works. This instrument records, on a strip of film 14 x 18 mm., picture of the object in the field of view, time, and angle-readings. The shortest interval in this case between exposures is one-fifth of a second. The kinotheodolite requires two—better three—stations. Both instruments have been described in the *Zeitschrift für Instrumentenkunde*.

In lecture (*f*) Dr. Raethjen described his kinematogrammetric method of measuring aeroplane direction and speed, in which his apparatus, together with the photograph of the aeroplane, projects an oriented system of co-ordinates on the film as if it were drawn upon the sky. A description has been published in *Bildmessung und Luftbildwesen*, 1929, No. 3.

The last of the lectures described an aerophotogrammetric method, and was illustrated by photographs taken from the *Graf Zeppelin* in February, 1929. This method has the great advantage over the two foregoing, that the aircraft is not earthbound by having to remain in the neighbourhood of the instruments.

Road-making of the American Expeditionary Force in the Great War. A historical report of the activities of the Engineers of the A.E.F. has been published, from docks and harbours, railway construction, camps, water-supply, electric power central stations to the procuring of building material. Out of this report certain particulars about roads have been extracted for three reasons, (1) neither in the German nor in the French post-war literature are such detailed reports to be found, (2) road-making was precisely the branch in which the Americans were widely mechanized, (3) the importance of military road-construction must increase as armies become more and more motorized. Two quotations are given in further justification :—" The greatest significance of the Engineers in a future war will probably be for the maintenance and improvement of the lines of traffic, and their highest aim must be, for all possible eventualities serviceable roads." " It follows from the late war that our Engineers up to 80% and more will be occupied with road-making and bridge-making."

Many of the figures are instructive. Thus, for an army of half a million, the Chief Engineer in Washington in July, 1917, estimated that there would be necessary for road-making proper 3,000 trained workmen, 6,000 assistants and 1,500 drivers ; for quarrying, 1,500 trained men, 3,000 assistants ; grand total, 15,000, or 3·3% of the whole force.

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This figure is high, especially when compared with the allowance of Pioneers to each German Division at the beginning of the War, viz., 1%.

By the end of October, 1918, there had arrived in France 36 companies for road-making, and 18 companies for quarrying, or about 11,000 men in all; who were quite insufficient. Other formations had consequently to be called upon to furnish labour; and the more so as operations extended. Finally, at the beginning of November, while the American 1st and 2nd Armies were carrying out the Argonne offensive, 28,300 men were occupied in road-making, or about 4% of the fighting troops. By March 1st, 1919, when the troops were flooding back to the ports, and the repairs, which had been sparingly carried out during the winter, had to be hurried on, the number employed on roads had risen to 110,000.

As regards road-metal, the total yield of all quarries in the American area and forward L.-of-C. amounted in September to 55,000 tons, and in November to 85,000, against 100,000 tons required.

On the L.-of-C. in the spring of 1919 seventy-eight quarries delivered 50,000 tons of road-metal a week, solely for roads; while in the ten days, 11th–20th March, 127,000 tons were used on the roads occupied by American troops, and in three and a half months over one million tons.

It appears from these figures that the American Army in France narrowly escaped a fiasco owing to the breakdown of the roads, and that this escape was due to the opportune cessation of hostilities.

The deductions are made that the demands on road-making and road-maintenance in war are so heavy that they can only be met when a perfect organization has been worked out beforehand, and men, machines and transport are provided in sufficient numbers. A necessary limit to the personnel can, however, in modern road-making be made up for by an increase in the number of machines.

A Life-belt knapsack. The inventor of the "Sändig" combined knapsack and life-belt set himself the task of finding a means by which the fully-equipped soldier could be safe from the danger of drowning without having to carry the extra load of a life-saving device. He ruled out of consideration any rubber contrivance needing pumping up, because of its not being ready when the emergency arises, and because the slightest damage puts it out of action. He also ruled out a cork-belt as too heavy and cumbersome for marching.

As regards size the "Sändig" differs practically not at all from the service equipment, and in weight not materially. It can be pierced by bayonet or bullet, and still perform its function. It will keep the fully-equipped soldier above water when worn as a knapsack. When worn as a life-belt the soldier can use his rifle in the water.

Several packs together can form a machine-gun raft, and two kept apart by poles will make a floating stretcher. What will interest the soldier more is that the "Sändig," when opened and laid out, adds to his comfort very greatly owing to its soft padding.

The article is illustrated with all the appropriate photographs.

Early Military Wireless. *Telefunken* for September, 1929, recalls the first war use of wireless telegraphy to memory. Two German columns operating against the Herreros twenty-five years ago kept in touch by this means, and were thus enabled to bring the operations to a successful

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conclusion. The claim of "first war use" cannot be substantiated. Successful use had been made of wireless in the Russo-Japanese War, when, for instance, a turning movement by Japanese cavalry was reported to Russian Headquarters in time for counter-measures to be taken. Previous to that, without having any such striking success to record, we had used wireless telegraphy in the South African War.

Increase of Performance in Infantry Weapons. Capt. Däniker, of the Swiss General Staff, adopts the method of starting from weapon-effect and drawing therefrom conclusions for the demands which may be made upon the weapon itself. As regards where this weapon-effect is to be sought he points out that hand firearms work through the sheaf of fire, or cone of bullets, for not only machine-guns or a number of rifles produce a cone, but also the single infantry rifle does so—a cone in this case which certainly as regards time is a very thin one.

To judge of a cone of fire, the first item is its shape, *i.e.*, whether the trajectory is flatter or more curved, the next is its space-thickness, depending on dispersion in height, length and breadth, and the last, its time-thickness. The ideal lies in a cone which is capable of regulation according to circumstances.

Comparative heights and breadths of 50% dispersion at 300 metres are then given in a table for various heavy machine-guns (Maxim, Hotchkiss, Vickers, Colt), for light machine-guns (Furrer and ZB 26), and for light machine-guns on light carriages (Madsen, Furrer and ZB 26, the two last on recoil-absorbers).

The figures show that the stabilized machine-gun with the company is in the right place to take over the tasks hitherto entrusted to the heavy machine-gun, and which the light machine-gun has been unable to perform. Captain Däniker is emboldened to ask whether the stabilized light machine-gun may not replace the heavy machine-gun altogether. —(*To be concluded.*)

The Great British Wireless Exhibition in London, 1929. At this date the interest lies less in what was exhibited than in how it appeared to German eyes. Herr Dickes has a great deal to praise in the exhibits, but finds Olympia far too small for such an exhibition, and that in the number of stands, number of exhibitors and especially in the number of separate sound-proof rooms for demonstration purposes the British exhibition is far behind the latest German Wireless Exhibition (*vide R.E. Journal*, September number).

Of valves, Herr Dickes was told that English valves were the best in the world. He does not contest this statement, but thinks there should be added to it that they are undoubtedly the most expensive. He found that great progress had been made in development of the S.G. valve, that they were to be found in numerous receivers and that 60% of all receivers on show were using them as H.F. amplifiers. Cossors are praised for eliminating microphone-effect by strengthened parts.

Of receivers, the English practice seems to be to make them general service, for battery drive or mains drive, and also for reproducing gramophone records. Of those shown 75% were boxed receivers, some of which were of really excellent quality. Two are deserving of special mention, Box o' Trix made by Eric J. Lever, Ltd. (1 valve), and a 4-valve

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receiver made by the Rees Mace Manufacturing Co., Ltd. Of mains-operated receivers, the Philips is praised as pleasing by its compactness. More than in Germany, an extended use of mains-operated receivers in Great Britain is prejudiced by the manifoldness of voltages, frequencies and different kinds of current. Besides, perhaps less than 40% of all British households have electric light at all. In the face of these facts battery-drive is likely to hold its own for some time to come, but the amount of apparatus for mains working exhibited was surprisingly large. A noticeable receiver was a Marconiphone Co. 5-valve with three stages of H.F. amplification using three screened-grid valves. Generally it appears—at least in England—that multiple-valve receivers are dying out.

Extraordinarily numerously represented were the so-called radio-gramophones, or combined broadcasting receiver and gramophone, eminently suitable for places of entertainment having no orchestra, for a turn of the hand gives wireless instead of gramophone, or the other way about, when there is a pause in the wireless programme. Regarding sources of current, Herr Dickes says of the comparatively few accumulators and H.T. batteries shown, that they do not appear to be inferior to German products. All accumulators were lead-plate, the Edison accumulator not being represented: a sign that the alkali-accumulator has not yet found its way into British broadcasting. Very little apparatus was shown for use with mains, the explanation being that, as in Germany, one has already got on to the building of mains-operated receivers. A very fine all-metal rectifier was, however, shown by the Westinghouse Brake and Saxby Signal Co., Ltd. It is made in two patterns, for H.T. and L.T., each pattern being built for varying performances. These all-metal rectifiers need no attention, have no parts that wear out, but slight fall of voltage, and a high degree of efficiency.

The trumpet loudspeaker has died out also in England, and the electromagnetic is beginning to yield to the electrodynamic. The electrostatic loudspeaker was not represented. Amongst components, condensers, coils, etc., nothing new could be discovered. They are neither better nor worse than their German counterparts.

On the subject of literature, besides the four well-known leading wireless journals, mention is made of *Television*, which chiefly does propaganda for Baird's system, and *World Radio*, the official organ of the B.B.C. The latter is praised for publishing the Brussels Laboratory Frequency-charts of European Broadcasting Stations, an example which "it would do no harm" if German journals would follow.

Water-supply in the American Army in and after the Great War. Compiled from two sources, the historical report of the Chief Engineer of the American Expeditionary Force, and a later article by one, Scott, "Water-supply in the Field Army," which appeared in *The Military Engineer.*

This first article deals with organization, which appears to have been as follows:—

(*a*) Projects and Design. Where the responsibility for these lay depended upon whether they were for the Armies or for the Lines of Communication. In the case of the Armies the responsible person was the Chief of the Water-supply Depart-

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ment in the office of the Chief Engineer, American Expeditionary Force. In the case of the Lines of Communication the officer responsible was the Chief of the Water-supply Department in the office of the Chief Engineer, L.-of-C.

(*b*) Stores. Responsibility for provision and replacement rested upon the Director of Engineer Services and Technical Stores at the Headquarters of the L.-of-C. This officer had a Chief of the Water-supply Department of his own Staff serving under him, and was himself under the Chief Engineer, A.E.F.

(*c*) Execution of Work. This was done by the 26th Engineer Regt., the commander of which was both head of the Water-supply Department in the office of the Chief Engineer of the Force, and head of the Water-supply Department in the office of the Director of Engineer Services and Technical Stores ; an arrangement which must surely have done much to ensure smooth working.—(*To be continued.*)

The Journal of Explosives. A congratulatory notice on the completion of twenty-five years of issue. Thanks are included that the journal, in addition to its work for explosives in civil life, has had a prominent part in the development of military explosives, especially by publishing the results of foreign experiments, trials and successes. It is hardly possible to avoid referring to the fact that so far from this being the original intention of the magazine, it was started with the pious hope, " through the improvement of war material so to increase the dangers of war as to make peace certain." The same idea occurred to a Frenchman, H. Noalhat :—" *Le complètement de nos moyens de meurtre sera l'aurore de la paix universelle.*"

(*February number*, 1930.)—*Increase of Performance of Infantry Weapons* (*concluded*). Capt. Däniker, before discussing the advantages of replacing the heavy machine-gun by the light machine-gun on a carriage, has to deal with two points, nature of feed and cooling-system. Present practice is for the light machine-gun, on account of being served by one man, to have a magazine, and for the heavy machine-gun, in order to get long continuous fire, to have a belt. Conversion of the light machine-gun to belt-feed is possible, and has been done in the case of aeroplane armament. Or, since magazines can be changed very rapidly, the magazine might be retained in the stabilized light machine-gun. The chief disadvantage would then be the extra weight. As regards cooling, the light machine-gun is air-cooled, the heavy machine-gun water-cooled. Views about cooling-systems are even now much divided ; but in the war both systems did good service. From the experience of the Hotchkiss it may very well be accepted that air-cooling is also a possibility even for heavy machine-guns. It also seems likely that in time a serviceable automatic air-cooling system will be found. Or, again, light machine-guns for special purposes may be given water-cooling.

There is consequently nothing in the way of putting those light machine-guns, which are to be used for replacing heavy machine-guns, on an equality with the latter also in these two points, by comparatively simple reconstruction.

Even if it is decided to convert the light machine-gun on light carriage

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to belt-feed and water-cooling, it will still have a large number of components in common with the present light machine-gun. The training-question also comes in.

Infantry-fire can be classified as short range and long range. Each of these classes can be divided into two, viz., fire with narrow cone against clearly visible targets and with good observation of results, and fire with large cone against targets not exactly located, and with observation of results difficult. At short range these two kinds of fire cannot be provided by one and the same weapon; the narrow cone falls to the rifle; the larger cone, lighter in space but denser in time, is the province of the machine-gun. At long range both kinds of fire can be provided by one and the same weapon, the heavy machine-gun, or equally well by the light machine-gun on light carriage.

Against the efforts towards unification there is the tendency—certainly not unjustified—to carry through a separation of calibre. Since the automatic rifle and the light machine-gun are both for short-range work they might easily go over to a lighter bullet with very great muzzle-velocity. This is important, as it would simplify considerably the manufacture of a serviceable, not too heavy, automatic rifle. That bullet-effect would remain sufficient has been shown by Gerlich (*vide R.E. Journal*, Sept., 1930, p. 552). The great advantage of separation of calibre would be that the light weapons, rifle and light machine-gun, can become lighter without prejudice to their effect. The heavy machine-gun from this separation would reap an advantage only if its bullet becomes heavier. This will result in no economy of ammunition unless the explosive bullet is introduced. In this case it will be able to operate effectively against aeroplanes. From trials it appears that the necessary bullet would have to weigh at least 50 grammes (say 1¾ oz.). Such a weapon would be too heavy to serve the infantry as a heavy machine-gun.

The advantages of a separation of calibre in the infantry are thus not as convincing as they appear at the first blush; at any rate, not until various other points are cleared up. Opposed to them stands the great disadvantage—the destruction of the unity of infantry ammunition. This disadvantage is now so much the more important, since the stabilization of the light machine-gun by means of the recoil-absorber has opened up promising perspectives.

Water-supply in the American Army in and after the Great War (concluded). The whole of the water-supply for the A.E.F. was thus carried out by the Water-supply Regiment (26th Engineers), which had ample stores, and which furnished detachments and working parties as and when required on the L.-of-C. or in the zone of the armies. It had to increase the supply in the ports of disembarkation, to find fresh sources of supply for camps, depots and hospitals, and to bring existing supplies in towns and villages up to the requirements of the troops, both as regards quantity and cleanliness. The chief source of fresh supplies whenever feasible was artesian wells, which had the advantage of rendering filtering arrangements unnecessary. Where artesian wells were not feasible, water was generally obtained by suction pumps, or directly from rivers, when it had to be filtered and disinfected. Some

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of the quantities which had to be provided daily were, at St. Nazaire, over three million gallons; in each of the five largest hospitals, half a million gallons. These quantities were insufficient to allow of water-closets; so that excreta had to be burnt. The largest sterilization station was at Tours, and dealt with between 3½ and 4½ million gallons daily. There were nine laboratories specially equipped for water-analysis, and in most cases affiliated to a medical laboratory. Along the railways used by the American troops the supply of water had to be materially increased. An idea of the difficulties met with is given by the following instance. At St. Nazaire, which lies on granite, the peace-time arrangement was to carry water from a spring 15 miles away. The Americans hoped to make sufficient provision by storing the winter rainfall in a new 350 million gallon reservoir. The dry winter of 1917–18 disappointed these hopes, and in the spring of 1918 a pressure-line had to be run 15 miles from the spring. The supply still proving insufficient a reservoir had to be constructed by throwing a dam across one of the mouths of the Loire.

The highly specialized and centralized organization which had grown up in war fulfilled its purpose under the circumstances then and there existing, for that particular theatre and for that particular warfare. It was hardly likely to survive in peace. The Keller Committee of 1919, which laid the foundations of the present American Engineer organization, laid down the entirely new principles of decentralization and as little specialization as possible.

According to the present organization, the troops of all arms are responsible for providing sufficient water for their own needs. Their labours to this end extend, and are confined to, maintaining or improving existing wells, springs, and reservoirs, and making watering-places. As the Pioneer regiment belonging to each division has to carry out every kind of engineering work, water-supply is included in its duties, and for this purpose it carries hand and force pumps, sailcloth containers, and water sterilizers; but it only assists the troops by improving their arrangements.

At Corps H.Q. the same holds good. There are no special water-supply troops, but special water-supply equipment is held in the Pioneer Park, enough for twelve watering-places of 3,500 gallons daily each. If water-supply is required on a scale beyond the power of the Corps Pioneers, the Army Water-supply Battalion will send assistance.

This latter is a mechanized unit of three companies (two provision, one maintenance), detachments of which are responsible for provision and maintenance of water-supply in each of the sectors of the Army area.

The co-ordinating hand of this decentralized system is that of a special officer on the staff of the Major-General commanding the Engineers at Army H.Q. He is the latter's adviser on water matters, orders the necessary stores and distributes them, issues type plans, collects and distributes all information about water, and regulates uniformity of procedure.

In many other armies one is inclined still—or once again—to look upon the question of military water-supply as something negligible; the

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American Army, on the other hand, has faced the question and done well in creating an organization thoroughly adaptable to circumstances.

The new Tefag-Ristow Wireless Alarm. Ristow is the name of the police captain who invented this alarm to save watch-keeping in police-stations, which must be able to accept a call at any moment, day or night; while Tefag appears to be the abbreviated name of the Telephonfabrik Aktiengesellschaft of Berlin which is bringing it out. Capt. Ristow's alarm is an improvement on existing wireless alarms, as it is less affected by atmospherics and by interference from other stations. His patent lies in the call being given, not by the appropriate impulses sent out by the calling-up sender working a relay directly, but by a local circuit-closer actuating a delay-action relay after a preliminary signal, a dash lasting three to six seconds. If the call appropriate to the station is not now received, the arrangement is self-restoring by means of a current-impulse pendulum.

The article is unnecessarily marred by its claiming as a record that wireless telegraphy was recently used in France for the first time between two wireless stations, both of which were in motion, actually, an aeroplane and a tank. It is perhaps a pity that the craze for records should be allowed to escape from sport and the newspapers. Science may surely dispense with such brightness as records afford.

Communication between two wireless stations both in motion is as old as wireless telegraphy in ships, say 25 years. Wireless reception in a moving station on land is as old as reception in trains, say 12 years. Wireless communication between aeroplane and moving tank was carried out at Farnborough in 1924; and no reason is known why it should not have been done in France before that date.

Indigenous Motor-spirits and Motor-oils. With the increase of motorization the question of to what extent a nation can supply from internal sources its own needs in motor-spirits and oils is of vital importance. Germany, being without earth-oil, has started putting her house in order, as this article shows. A general survey is given beginning with the sun's energy and leading through earth-oil, pit-coal, brown-coal, and vegetation rich in cellulose to petrol, benzole, brown-coal petrol, and alcohol respectively. Another branch, cutting out the vegetable world, arrives at alcohol *via* water-power, electricity, carbide, acetylene and acetaldehyde. The items of chief interest in this chart are benzole, produced from pit-coal; and brown-coal petrol, produced from brown-coal.

Benzole is Germany's greatest indigenous motor-spirit. It is used both for motor-cars and aeroplanes. Where in other countries unmixed petrol is used, the Germans have largely gone over to petrol-mixtures, *e.g.*, petrol 40%, alcohol 20 to 40%, benzole 40 to 20%, thus furnishing no less than 60% of what they consume out of home products. Brown-coal petrol is a purely German spirit, its origin being the brown-coal found in Central Germany. It is the so-called synthetic petrol of the J. G. Farbenindustrie, obtained by their high-pressure hydrogenization process, and hardly differing chemically from earth-oil petrols. A mixture of this synthetic petrol with benzole is sold under the name of Motorin, a 100% home product.

The article then deals with the chief requirements of a good motor-

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spirit, good volatility, mechanical and chemical purity and the requisite resistance to compression. Volatility is best judged by the vaporization-curve and Ostwald's characteristic. Chemical purity means principally the absence of resin-forming and corroding substances. Firmness under compression depends upon the nature of the petrols where petrol alone is used. Of these the best anti-knock are the Baku petrols. In the case of mixtures it depends upon the content of the natural anti-knock liquids like benzole and alcohol, or the artificial ones like lead (tetra) ethyl and ironcarbonyl. (*To be continued.*)

Technics and the State, from Babylon to the present day, by S. Hartmann, published by Cotta's, Berlin, price mks. 2/80. The author traces the connection between technics and the State, and points out that the closeness of this connection, whenever technics have been sufficiently advanced, is the true State-building and State-preserving power. He shows how the formation of States, their growth, and the high development of culture, *e.g.*, in Babylon, Assyria and in Egypt, were closely bound up with the skill of their waterworks-engineers, and how Rome grew to be the mistress of the world on its highly developed road-building. He explains that the Middle Ages in Europe produced no lasting great State, because technics were kept down by the selfishness of the guild-system. Finally, he cries out for statesmanship to lead and direct the technics of to-day.

F.A.I.

CORRESPONDENCE.

EDUCATION OF R.C.E. OFFICERS.

(The following has been communicated by Major G. R. Turner, M.C., D.C.M., R.C.E., the Corresponding Member for Canada.)

After graduation from the R.M.C., Kingston, officers commissioned in the R.C.E. are posted to Halifax, N.S., for 15 months' regimental duty. As the Royal Canadian School of Military Engineering is located at Halifax, the young officers have the opportunity of gaining instructional experience as well as experience on Engineer Services and Works.

On completing this 15 months' regimental duty, the officers proceed to McGill University, where, under an arrangement with the University authorities, they undergo a special course, and can obtain in one year, if successful in their examinations, the degree of Bachelor of Science in Civil Engineering.

These officers, who have graduated from McGill in May, proceed to England in the following August to undergo the regular course at the S.M.E., Chatham. In addition, attachments to various R.E. units before the officers return to Canada are authorized if funds permit.

This system provides civil engineers, but no fully-trained electrical and mechanical officers, and McGill University will not give a degree in

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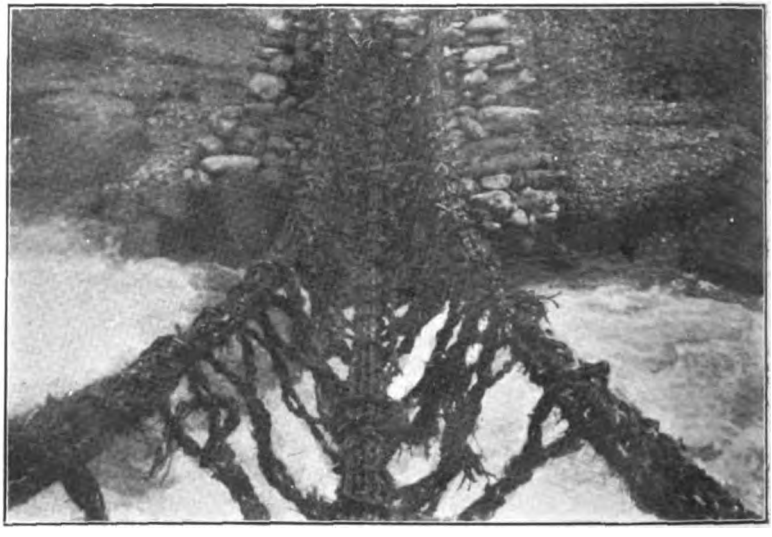
WILLOW TWIG BRIDGE.

Near Dras, Ladakh, Kashmir.



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electrical or mechanical engineering after one year's study there to graduates of the R.M.C. unless these graduates have completed third-year work in these subjects. Owing to the amount of laboratory work involved, it is impossible for young officers to cover the third-year work in these subjects by private study.

In order to provide electrical and mechanical engineers, three young officers who graduated from R.M.C. in June, 1930, and who are now at Halifax, have been enrolled at the Nova Scotia Technical College, Halifax, in third-year electrical engineering. The third-year work in electrical and mechanical engineering is practically identical; consequently, these officers could enter the final year at McGill and obtain the degree of Bachelor of Science in either of these branches.

The choice of electrical or mechanical for the final year at McGill will depend on the reports obtained from Nova Scotia Technical College, and, if officers show no particular aptitude for these particular branches of engineering, they will be required to enrol in the fourth-year civil engineering course at McGill.

Consideration is being given to the question of making the third-year electrical and mechanical course at Nova Scotia Technical College obligatory for all young officers with the final year normally in civil engineering at McGill, and only officers showing a particular aptitude in electrical and mechanical subjects being allowed to continue in these subjects at McGill. For normal work on engineer services in Canada, it is considered that the third-year electrical and mechanical course will suffice, as the fourth year in these branches deals mainly with design.

To summarize, the educational qualifications of R.C.E. officers will be:

Royal Military College: four years.
Nova Scotia Technical College: one year (electrical and mechanical).
McGill University: one year with degree of B.Sc. in civil, electrical or mechanical.
S.M.E., Chatham, England: One and a half years (including attachments).

This will ensure a high standard of engineering education to the great advantage of military engineers in their connections with the engineering profession generally.

WILLOW TWIG BRIDGE.

DEAR SIR,

The two annexed photos show a bridge near Dras, Ladakh, Kashmir, made entirely of willow twigs; a good example of the use of local, and rather unpromising, materials. Such bridges are constantly made by the local inhabitants.

The span is about 30 feet, with a sag of about 5 feet. The footway consists of a cable of 9 or 10 willow ropes, each about 4½ inches in circumference, and the handrails of about 6 similar ropes. The ropes are laid similarly to hemp ropes. The anchorages are made by weighting down the ends of the main cables with heavy stones.

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The bridge can, of course, be used by foot passengers only. It was tested with a live load of 13 stone centrally placed.

Not a scrap of any material, other than willows, was used in its construction; the reason of this is that, besides poplar, willow is the only tree growing at that altitude (10,000 feet above sea level).

I believe there are longer bridges made of the same materials in that part of the world, and it would be interesting to know the maximum span extant.

Yours, etc.,

F. C. MOLESWORTH, *Colonel.*

R.E. CO-OPERATION WITH CAVALRY.

Fieldworks and Bridging School,
S.M.E., Chatham,
4th October, 1930.

The Editor, *R.E. Journal.*

DEAR SIR,

In the *R.E. Journal* of September, 1930, there appeared an article entitled "R.E. Co-operation with Cavalry." In this article it was stated that two Field Troops could construct a medium bridge 105 ft. long in half-an-hour from the arrival of the equipment at the site, which is assumed to be an "average" one.

The bridge referred to consists of the bridging equipment of the Cavalry Division, so that two of the piers are trestles and two are pontoons. To complete such a bridge in half-an-hour is quite beyond the powers of the most highly-trained sappers. Several minutes must elapse before enough stores are unloaded to start any actual construction. Then a trestle has to be assembled and launched and the other has to be taken to the far side and launched there. The actual results on manœuvres, etc., show that, under easy conditions, a more reasonable figure would be 1½ hours, increased to 2½ hours by night.

Yours faithfully,

I. S. O. PLAYFAIR, *Major, R.E.*

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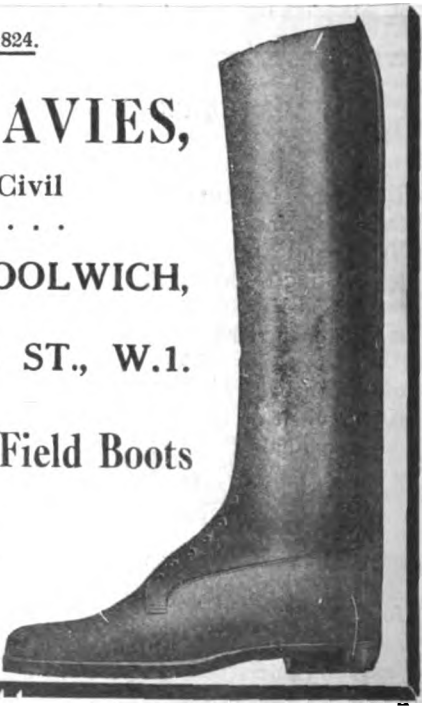

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